THE

ELEMENTS

OF

PHYSIOLOGY.

London:
Printed by A. & R. Spottiswoode,
New-Street-Square.

THE

ELEMENTS

OF

PHYSIOLOGY,

BY

J. FRED. BLUMENBACH, M.D. F.R.S.

PROFESSOR OF MEDICINE IN THE UNIVERSITY OF GÖTTINGEN.

TRANSLATED FROM THE LATIN OF THE FOURTH AND LAST EDITION,

AND SUPPLIED

WITH COPIOUS NOTES,

BY

JOHN ELLIOTSON, M.D. CANTAB.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS;
PHYSICIAN TO, AND LECTURER ON THE PRACTICE OF MEDICINE IN, ST. THOMAS'S HOSPITAL.

FOURTH EDITION.

Quæramus optima, nec protinus se offerentibus gaudeamus: adhibeatur judicium inventis, dispositio probatis.

QUINTILIAN.

LONDON:

PRINTED FOR

LONGMAN, REES, ORME, BROWN, AND GREEN,

PATERNOSTER-ROW.

1828.

TO

PROFESSOR BLUMENBACH.

My dear Sir,

Some few persons I do envy, and you are of the number. In a green old age, still enjoying great mental activity and a most cheerful disposition, living, like so many of your scientific countrymen, in a little village, with the utmost simplicity, a stranger to the desire of wealth and the absurd ambition of worldly importance, but holding highly responsible offices in an illustrious though humble university, — you are celebrated in every country for an extensive and profound knowledge of natural history, for the number of facts which you have yourself contributed, for a perfect acquaintance with all the writings of others, for the production of numerous works, translated into various languages, and distinguished by copiousness and accuracy of information, sound opinions, and a conciseness, perspicuity, and elegance that are seldom seen; and no less for the powerful impulse which you gave to the study of natural history, and especially of the Natural History of Man, almost before the present generation existed.

To you I take the liberty of dedicating this work, and with the more delight, as I know from the happiness of personal acquaintance your liberal and amiable disposition, your attachment to England, and admiration of whatever is English.

Believe me,

My dear Sir,

Your very faithful friend and servant,

JOHN ELLIOTSON.

London, *March* 1*st*, 1828.

TRANSLATOR'S PREFACE.

SINCE the last publication of this work, a new edition of the original has appeared. The text contains no additions, and very few alterations, but the references are augmented. According to this, the present edition is re-modelled, and the whole translation has been carefully revised.

The notes are doubled in amount, and indeed may be almost considered perfectly new. Many points are for the first time examined, former notes are modified and enlarged, and the numerous and important discoveries lately made in physiology are introduced.

Every opinion defended is that which seems to me the fairest conclusion from our facts relative to the subject. I can never bow to authority in matters of investigation, but feel myself compelled *sentire quæ velim;* and, when a necessity for expressing an opinion exists, I hope always to have courage sufficient *dicere quæ sentiam.*

I have taken great pains to make myself master of all important physiological facts, and to reason correctly from them; to give every author the credit of originality which he deserves; and to be accurate in my references. But after all I may frequently have failed. If my inaccuracies cannot be excused on the ground of the number and diversity of the points examined, or my almost constant occupation with another branch of medicine, both as a lecturer and a public and private practitioner, I can only assure my readers that the detection of any failure in reasoning or inaccuracy of statement will be gratefully received, and that my highest object and happiness are the acquisition and dissemination of truth.

JOHN ELLIOTSON.

Grafton Street, Bond Street,
March 1. 1828.

THE AUTHOR'S PREFACE

TO

THE LAST EDITION.

WHENEVER my booksellers have informed me that a new edition of any of my works was required, my greatest pleasure has been at having an opportunity of correcting inaccuracies arising either from carelessness or the imperfection of human nature, and of adding in some places and altering in others; in short, of sending forth the production of my abilities in as improved a state as possible.

In preparing this new edition of my INSTITUTIONS of PHYSIOLOGY for the press, the same anxious wish has been considerably heightened by the importance of the subject, and by the approbation evidently bestowed upon the last edition from its translation into various languages,[a] not to mention other proofs of its favourable reception. I have endeavoured, therefore, to enrich it not so much with an addition of pages, as of various matter, and to render the whole as useful to students as possible.

The little figure which I have thought a very appropriate ornament for the title-page of the work, *viz.* a representation of the human body, made by Prometheus, but animated by Pallas, I borrowed from the relievo of a sarcophagus in the Capitoline Museum.[b]

May 7. 1821.

---

[a] Into *German*, by Jos. Eyerel. Vienna, 1789.
Ed. 2. Ib. 1795.

Into *Dutch*, by two writers. First, by P. J. Wolff, with a preface by Rud. Forsten. Harderwick, 1791. Afterwards, by James Vosmaer. Ib. 1807.

Into *English*, by two writers likewise. First, by C. Caldwell, Philadelphia, 1795.

Afterwards, by J. Elliotson. London, 1815.

Ed. 2. Ib. 1817. This second edition is a curiosity in typography, being the first book printed by steam. The printers were Bensley and Son.

Ed. 3. Ib. 1820.

Into *French*, by J. Fr. Pugnet. Lyons, 1797.

Into *Spanish*, by Jos. Coll. Madrid, 1801.

Into *Russian*, by Borsuk Moiseew. Moscow, 1796.

[b] This the translator has thought it superfluous to insert.—J. E.

THE AUTHOR'S PREFACE

TO

THE FIRST EDITION.

THE same considerations which led BOERHAAVE, and after him HALLER, to write their Compendiums of Physiology, induced the Author to compose these Institutions.

The former says, "*that a teacher succeeds better in explaining his own thoughts than in commenting upon a work written by another,—that his instruction will be clearer, and his language generally animated,*" &c.[a]

The latter, "*That, although he formerly used* BOERHAAVE'S *work as a text-book, he afterwards lectured upon one written by himself, because anatomy*

[a] Pref. to the *Institut. Medic.* Leyden. Fourth edition.

had been so improved since the time of BOERHAAVE, *as to have become almost a new science.*"[b]

What HALLER said at that period respecting anatomy, will be allowed to apply much more forcibly at present to Physiology, by any one who considers the most important parts of the science,—the principal purpose of respiration, animal heat, digestion, the true nature and use of the bile, the function of generation, &c.

More, therefore, must be ascribed to the age than to the Author, if in these Institutions, after so many modern physiological discoveries, he has delivered doctrines more sound and natural than it was in the power of his most meritorious predecessors to deliver.

Whatever he can claim as his own, whether really new or only presented in a new view, will easily be discovered by the learned and impartial reader: especially from the notes, in which he has treated some of these subjects rather more minutely than was compatible in the text with the conciseness of his plan.

[b] Pref. to the *Prim. lin. Physiol.* Göttingen. First edition.

He has been at great pains in arranging the subjects, so that the sections might succeed naturally and easily, and arise, as it were, one out of another.

He has not quoted a dry farrago of books, but a select number, in doing which, he has been desirous both of pointing out to students some excellent authors not commonly known, especially those who have professedly treated on particular branches of the subject, and of opening, besides medical sources of information, others not yet applied, he conceives, to Physiology, as they deserve.

He has referred to the best anatomical plates; most frequently to those of Eustachius, because he would wish every medical student to possess Albinus's edition of them, as the richest and most perfect work of the kind, or rather, he should say, as a treasure which can never be praised sufficiently.

He has indeed given some original engravings of parts either not represented at all by Eustachius, or not in the same point of view.[c]

[c] These are of the heart, eye, testis in its descent, and the ovum. The Translator has judged it unnecessary to have them copied, as English students rarely consult Eustachius, but study native anatomists, in whose works these parts are given with the others of the body.—J. E.

His grand object has been to deliver, in a faithful, concise, and intelligible manner, the principles of a science inferior in beauty, importance, and utility, to no part of medicine, if the words prefixed by the immortal Galen to his *Methodus Medendi*, are true, as they most certainly are: — " *The magnitude of a disease is in proportion to its deviation from the healthy state ; and the extent of this deviation can be ascertained by him only who is perfectly acquainted with the healthy state.*"

CONTENTS.

The Translator's Notes follow the section to which the subject of each respectively belongs.

The note on the characteristics and varieties of mankind, being an independent addition, is placed last, and begins at p. 539.

THE

ELEMENTS

OF

PHYSIOLOGY.

SECT. I.

OF THE LIVING HUMAN BODY IN GENERAL.

1. In the living human body, regarded as a peculiar organisation, there are three objects of consideration.[a]

The materials of its subsistence, afforded by the fluids;

The structure of the solids, containing the fluids;

Lastly, and principally, *the vital powers*, by which the solids are enabled to receive the influence of the fluids, to propel the fluids, and to perform various other motions; and which, as they, in a certain sense, constitute the essence of the living machine in general, so, likewise, are of very different orders, some being common to animals and vegetables, some peculiar to animals and intimately connected with the mental faculties.

[a] Thus, long ago, the author of the book generally included among the writings of HIPPOCRATES, *Epidemic.* VI. Sect. 8. § 19. said, " Those things which contain, are contained, or moved in us with force, are to be considered." This celebrated passage gave origin to the excellent work of ABR. KAAU BOERHAAVE, entitled, " *Impetum faciens dictum* Hippocrati *per corpus consentiens.*" L. B. 1745. 8vo.

2. But these three, although really distinct, and, therefore, distinctly considered by us, are so closely connected in the *living* system (the phenomena, conditions, and laws of whose functions, in the healthy state, are the object of physiology), that no one can be contemplated but in its relation to the rest.

For the materials of the body, although originally fluid, are naturally disposed to become solid; and, on the other hand, the solids, besides having been formed from the fluids, abound, however dry they may appear, in various kinds of fluid constituents, both liquid and permanently elastic, — gasiform, as they are termed; lastly, it may probably be affirmed that no fibril, during life, is destitute of vital power.

3. We shall now examine each of these separately; and, first, the materials afforded by the fluids, which form both the fundamental and most considerable[b] portion of our bodies.

NOTE.

Attempts have been made to specify the *elementary tissues* of which the various organs are composed.

Dr. Carmichael Smyth, in an admirable paper upon inflammation, considered the disease according to the *structures* which it affects, — the skin, cellular membrane, serous membranes, mucous membranes, and muscular fibres.[c] Dr. Pinel, some years afterwards,

[b] The great preponderance of the fluids is strikingly exemplified in an entire, but perfectly dry, mummy of an adult Guanche, one of the original inhabitants of the island of Teneriffe. It was sent to my anthropological collection by the illustrious Banks, and, with all its viscera and muscles, wonderfully dried, weighs only 7½lbs.

[c] *Medical Communications, by a Society for the Promotion of Medical Knowledge,* vol. ii. 1790. Read to the Society, Jan. 1788.

adopted this arrangement,[d] and Bichat at length suggested that all diseases might be considered in this manner, and distributed the structures, or elementary tissues, into twenty-one kinds: —

1. Cellular,	12. Fibro-cartilaginous,
2. Nervous, of animal life,	13. Muscular, of animal life
3. Nervous, of organic life,	14. Muscular, of organic life,
4. Arterial,	15. Mucous,
5. Venous,	16. Serous,
6. Exhalant,	17. Synovial,
7. Absorbent, with its glands,	18. Glandular,
8. Osseous,	19. Dermoid,
9. Medullary,	20. Epidermoid,
10. Cartilaginous,	21. Pilous.[e]
11. Fibrous (tendino-fibrous),	

This arrangement, Dr. Rudolphi remarks, is physiological rather than anatomical, and he distributes the elementary tissues into eight classes only: —

Cellular,	Tendinous,
Horny,	Vascular,
Cartilaginous,	Muscular, and
Osseous,	Nervous.[f]

The *primary solids*, of which these tissues are said to be composed, are, the cellular fibre, the muscular fibre, and the nervous fibre.[g]

[d] *Nosographie Philosophique*, 1797.

[e] *Anatomie Générale*, t. 1. p. lxxx.

[f] *Grundriss der Physiologie*, 68.

[g] See Appendix, by Dr. Copeland, to his translation of Richerand's *Nouveaux Elémens de Physiologie*, p. 553. sqq. Many writers have asserted the globular composition of various parts of the animal and vegetable frame. Lately, the cellular, muscular, and nervous structures were described as consisting of globules, and some novel views presented, by Dr. M. Edwards. (*Archives Générales de Médecine*, t. 3. Paris, 1823.) But the whole results have just been denied by Dr. Hodgkin and Mr. Lister, who repeated the examination with a much superior microscope. *Philos. Magazine*, August, 1827.

Another author professes to have made still more minute discoveries than Dr. Edwards. Dutrochet, *Recherches, Anatomiques et Physiologiques, sur la Structure Interne des Animaux et Végétaux.*

The *proximate principles*, or distinct chemical compounds of animal bodies, are:—

Albumen,
Fibrin,
Colouring matter of blood,
Curd,
Fatty matter, { olein, stearin,
Matters found in the bile,—cholesterin, erythrogin, asparagin, picromel?
Mucus, and probably some other products of glands at present but little understood,

Subject to great variety in different animals, &c.

Urea,
Cystic oxide, xanthic oxide,
Uric acid,
Erythric acid?
Purpuric aid,
Oxalic acid,
Acetic acid,
Butyric acid,
Formic acid,
Benzoic acid,
Sulpho-cyanic acid,
Sugar of milk,
Sugar of diabetic urine,

Not subject to variety; uniform in all instances.

The *elements*, or *ultimate principles* of animal bodies, into which the distinct compounds may be resolved, are:—

Hydrogen,
Carbon,
Oxygen,
Azote,
Chlorin, iodin, fluorin?
Sulphur,
Phosphorus,
Potassium,
Sodium,

Calcium,
Magnesium, silicium ?
Manganese ?
Iron.

The ultimate principles of vegetables may be considered the same as those of animals.

Vegetable proximate principles are very numerous; the following may be considered as the chief: —

Sugar,

Starch, Lignin, Gum, mucus, jelly, Extractive, colouring matters, bitter principles, Gluten, Oils, fixed and volatile,	All subject to endless variety as occurring in different plants.

Resins,

The following are constant in their character, or are peculiar to certain vegetables.

Various acids — Oxalic, citric, tartaric, malic, moroxylic, gallic, laccic, kinic, boletic, prussic, meconic, benzoic.
Various alkaline bodies — Quinina, cinchonina, morphina, strychnina, brucina, delphina, picrotoxina, atropia, veratrina, hyoscyamina.
Indigo,
Tan,
Suber,
Caoutchouc,
Wax,
Asparagin, ulmin, inulin, fungin, polychroite, hæmatin, nicotin, pollenin, emetin, sarcocol, olivile, medullin, lupulin, cathartin, piperin, &c.

SECT. II.

OF THE FLUIDS IN GENERAL, AND PARTICULARLY OF THE BLOOD.

4. The fluids of the body[a] may be conveniently reduced to three classes.

A. The *crude*; viz. the chyle, contained in the primæ viæ and destined to become blood; and matters absorbed on the surface and conveyed to the chyle.

B. The *blood* itself.

C. Those *secreted* from the blood, whether inert and excrementitious, like the urine; or intended for certain purposes in the economy: the latter may be permanently liquid, as the bile; or disposed to solidity, as the osseous and other plastic juices.

5. Of the first and third of these classes we shall hereafter speak, in treating of chylification, secretion, and the other functions to which each fluid appertains. At present our attention shall be devoted to the *blood*[b] — the chief and primary fluid — the vehicle of those successions of oxygenous and carbonaceous particles, that cease with life only — the nourisher of the frame — the source of almost every fluid — that *into* which the crude fluid is converted, and *from* which all the secretions are derived — and which, with the exception of some exsangueous parts, as the epidermis, the arachnoid, the amnion, &c., the vitreous substance of the teeth, the body of the crystalline lens, &c., is universally diffused through the system; in various proportions, indeed, according

[a] Suffice it, once for all, to recommend, on the chemical investigation of the fluids of the human body, J. Jacob Berzelius's *Föreläsningar i Diurkemien.* Stockholm, 1806—1808. two vols. 8vo.

[b] J. Hunter, *Treatise on the Blood, Inflammation,* &c. London, 1794. 4to.

to the various natures of parts, *v. c.* abundantly in the muscles, and still more so in certain viscera, as the spleen, placenta, and uterus at an advanced period of pregnancy; very sparingly, on the other hand, in the tendons and cartilages. [c]

6. The blood is a fluid *sui generis*, of a well known colour and peculiar odour; its taste is rather saline and nauseous; its temperature about 96° of Fahrenheit; it is glutinous to the touch; its specific gravity, though different in different individuals, may be generally estimated as 1050, water being 1000; when fresh drawn and received into a vessel, it exhibits the following appearances: [d]

7. At first, especially while still warm, it emits a vapour which has of late been denominated an animal gas, and shown to consist of hydrogen and carbon, suspended by caloric. [e] This, if collected in a bell glass, forms drops resembling dew, of a *watery* nature, but affording a nidorous smell, which is most remarkable in the blood of carnivorous animals, is peculiar, and truly animal. Much of this watery liquor still remains united with the other parts of the blood, hereafter to be mentioned. (C)

8. In the mean time the blood, when its temperature has fallen to about 78° Fahr., begins to separate into two portions. A coagulum is first formed, from the surface of which exudes,

[c] It is astonishing how variously physiologists have estimated the quantity of blood in a well formed adult. Allen, Mullen, and Abildgaard, make it scarcely more than 8 pounds; Harvey, 9; Borelli, 20; Haller, 30; Riolan, 40; Hamberger, 80; J. Keil, 100. The former are evidently nearer the truth. (A)

[d] J. Martin Butt, *De spontanea sanguinis separatione.* Edinb. 1760. 8vo. reprinted in Sandifort's *Thesaurus*, vol. ii. J. H. L. Bader, *Experimenta circa sanguinem.* Argent. 1788. 8vo.

[e] The *elements* of aëriform fluids of course exist in the blood; that they are not, however, in the *elastic state*, as so many physiologists formerly believed, was clearly shown in some experiments made by me during the year 1812, upon other mammalia. I found that a small portion of the purest air, infused into the jugular vein, excited palpitations, drowsiness, convulsions; and, if the quantity was a little increased, even death ensued. I have detailed these experiments in the *Medicin. Biblioth.* vol. i. p. 177.

The illustrious Bichat observed the same effects in his experiments. *Journal de Santé, &c. de Bourdeaux,* t. ii. p. 61. (B) as it were, a fluid of a yellowish slightly red colour, denominated *serum:* the more abundantly this exudes, the greater is the contraction of the glutinous coagulum, which has received the appellations of *crassamentum;* and, from some resemblance to the liver in colour and texture, of hepar sanguineum; of placenta; and, from the circumstance of its being surrounded by the serum, of insula. (D)

9. The crassamentum may, by agitation or repeated ablution, be easily separated into two constituent parts — the *cruor*, which gave to the blood its purple colour, — and the *lymph*, which on washing is forsaken by the cruor, and called, from its greater solidity, the basis of the crassamentum. The stronger affinity of the cruor for the lymph than for the serum, is proved by the necessity of violence to effect their disunion. By the removal of the cruor the lymph becomes gradually paler, till it is at length merely a white tenacious coagulum. (E)

10. Besides the watery fluid first mentioned, these are the three constituents of the blood, viz. the *serum*, the *cruor*, and the *lymph*, of each of which we shall presently treat more particularly. These, however, while perfectly recent, and in possession of their native heat, are intimately mixed, and form an equable, homogeneous fluid. Their relative proportion is astonishingly diversified, according to age, temperament, diet, and similar circumstances which constitute the peculiar health of each individual.

11. The *serum* is a peculiar fluid, the chief cause of the viscidity of the blood, and easily separable by art into different constituent principles. If subjected to a temperature of 150° Fahr. a portion is converted into a white scissile substance, resembling boiled *albumen:* the rest exhibits, besides the watery fluid so often mentioned, a turbid fluid of a *gelatinous*, or rather *mucous*[f] nature, which on cooling appears a tremulous coagulum. The serum is remarkable for the quantity of soda (mineral alkali) which it contains. (F)

[f] J. Bostock, *Medico-Chirurgical Transactions, published by the Medical and Chirurgical Society of London*, vol. i. 1809. p. 46.

12. The *cruor* has many peculiarities, in regard to both the colour and the figure of its particles.

It consists of *globules*, which in recent blood are of a constant form and size, and said to be $\frac{1}{3300}$ of an inch in diameter. Their form, indeed, has been a subject of dispute, but I am disposed to consider it as much more simple than some writers of great celebrity have imagined. I have always found it globular, and could never discover the lenticular shape which some have asserted that they remarked.

It has been likewise advanced, that the globules change their form while passing through a vessel of very small capacity, — that, from being spherical, they become oval; and, when they have emerged into a vessel of larger area, that they resume their globular shape.[g] This, although I would by no means deny it, I cannot conceive to occur during the tranquil and healthy motion of the blood, but should refer it to a spasm of the small vessels.

Their globular figure can be seen in a living animal only, or in blood very recently drawn: for they are soon unobservable, becoming a shapeless mass which resembles serum in every circumstance excepting colour.[h]

13. Their *colour* is red, and from it is derived the colour of the blood. In intensity it varies infinitely; paler in animals which have been poorly nourished or have suffered from hæmorrhage; more florid, when oxygenised[i] (rendered arterial, to use the common phrase) by exposure either to

[g] G. Chr. Reichel, *De sanguine ejusque motu experimenta*. Lips. 1767. 4to. p. 27. fig. 3. g.g.

[h] Consult Ever. Home, *Phil. Trans.* 1818. P. I. p. 172.

[i] Unwilling as I am to follow the example of those who, especially in modern times, delight in changing scientific terms, I cannot but think that the words *oxygenised* and *carbonised* may be advantageously substituted for arterial and venous: because arterial blood is contained in some vessels called *veins*, v. c. the pulmonary and umbilical; while, on the other hand, venous blood is contained in the pulmonary and umbilical *arteries*. In the same manner, the veins of the chorion in the incubated egg contain arterial; and the arteries, venous blood; — to use these expressions in their common acceptation. But we shall treat of the doctrine of the relation of oxygen and carbon to each kind of blood, in the section on respiration.

atmospheric air, or, more especially, to oxygen; darker when carbonised (in common language, rendered venous) and placed in carbonic acid gas or hydrogen.[k] The redness is most probably to be ascribed to the oxide of iron,[l] the quantity of which, however, is so minute, that it has been most variously estimated. (G)

14. The last constituent principle of the blood to be noticed, is the plastic *lymph*, formerly confounded with the serum. This has been called the basis of the crassamentum, the glutinous part, the fibre or fibrous matter of the blood, and, like the caseous part of milk, and the gluten of vegetables, been discovered by late analysis to abound in carbon and azote. (H)

15. It is properly denominated plastic, because it affords the chief materials from which the similar parts, especially the muscles, are immediately produced; nourishes the body throughout life; repairs wounds and fractures in an extraordinary manner; fills up the areæ of large blood vessels when divided;[m] and forms those concretions which accompany inflammations,[n] and that remarkable deciduous membrane found in the recently impregnated uterus for the attachment of the ovum.

16. Thus much have we said respecting the constituent parts and nature of the blood, the most important fluid of the animal machine, — a fluid which *excites the heart* to contraction; which distributes *oxygen* to every part, and conveys away the *carbon* to the excretory vessels, giving rise, by this change, to *animal heat;* which supplies the *materials* of the

[k] Consult, among others, J. Ferd. H. Autenreith, *Experimenta et observata de sanguine, præsertim venoso.* Stuttg. 1792. 4to.

[l] Berzelius, *Annales de Chimie et de Physique*, t. v. Mai, 1817.

[m] T. F. D. Jones, *On the process employed by nature in suppressing the hemorrhage from divided,* &c. *arteries.* London, 1805. 8vo. Translated into German, and supplied with notes by G. Spangenberg. Hanov. 1813. 8vo.

[n] Such are those *spurious membranes* found exuded on the surface of inflamed viscera, *v.c.* those cellular connections between the lungs and pleura after peripneumony, and the tubes observed within the bronchia after croup; such also are those artificial ones, called, from their inventor, Ruyschian, and made by stirring fresh blood about with a stick.

solids originally, and ever afterwards their *nourishment*; and from which all the *other fluids*, with the exception of the crude (4), are *secreted* and derived. Of the multifarious importance of the blood, we shall speak particularly hereafter.

NOTES.

(A) Most cold-blooded animals, as fishes and the amphibia, have a much smaller proportion of blood and fewer blood-vessels than those with warm blood, though a much greater number of colourless vessels arising from the arteries. In an experiment which Blumenbach made on this subject, he "obtained from twenty-four adult water-newts (lacerta palustris), which had been just caught, and weighed each an ounce and a half, ℈iiiss. of blood. The proportion to the weight of the body was as $2\frac{1}{2}$ to 36, while in healthy adult men it is as 1 to 5."[o]

(B) Dr. Magendie stated, in 1809, to the Institute, that this assertion is incorrect. If air is injected rapidly, the animal screams and dies in a moment: but if slowly, he informs us that no inconvenience results, and that some animals bear the injection of enormous quantities without perishing.[p] Dr. Blundel injected five drams into the femoral vein of a very small dog, with only temporary inconvenience, and subsequently three drams of expired air even without much temporary disturbance.[q] Nysten has established, that many gases soluble in the blood, as oxygen and carbonic acid, may be thrown into the circulating system in very large quantity without serious inconvenience; while danger often ensues upon the introduction of those which are sparingly or not at all soluble in the blood.[r]

In the same way, if about 15 grains of bile are rapidly introduced into the crural vein of an animal, instant death occurs; but, if slowly, no inconvenience results. This quantity may be even rapidly injected into the vena portæ without injury, and so likewise may atmospheric air, probably because the extreme subdivision of the vessel acts like slowness of introduction, — causes the complete diffusion and dilution of the bile, and solution of the air, before it reaches the heart.

[o] *Comparative Anatomy*, ch. xii. ed. 1. p. 245. Translated by Mr. Lawrence.
[p] *Précis Elémentaire de Physiologie*. 2d edition, 1825. t. ii. p. 433. sqq.
[q] *Med. Chir. Trans.* 1818. p. 65. sq. [r] Magendie, l. c.

If warm water is introduced (an equal quantity of blood being first removed to prevent over distension) mere debility ensues, proportionate to the quantity; but if oils, or mucilages, or an inert impalpable powder, are injected, life is at once destroyed by the obstruction of the minute ramifications of the pulmonary artery.[s] Poisons act powerfully if injected into the veins; and, as will presently be mentioned, medicines thus introduced, exert their specific powers on the different organs.

(C) When blood, venous or arterial, is placed in the vacuum of an air pump,[t] or coagulates in the air,[u] it emits a quantity of carbonic acid gas. Professor Brande obtained two cubic inches from every ounce of blood; Dr. Scudamore less than half a cubic inch from six ounces. The quantity is said to be much greater after a meal, and much less if the blood is buffy.[x]

(D) Blood coagulates when it has escaped from the body, whether warm or cold, in the air or in vacuo, diluted within certain limits, or undiluted, at rest or in motion. Within the vessels, rest, which causes a cessation of intercourse between the motionless portion and the general mass, always disposes it to coagulate. Yet its coagulation, after escape from the body, is said to be accelerated by motion, a high temperature, and a vessel calculated to preserve its temperature, by a vacuum, and by the stream from the vessel being slow, and *vice versa:* in short, by every circumstance which favours the escape of carbonic acid gas, and to be proportioned to the quantity of carbonic acid gas evolved; this being evolved during the coagulation, and ceasing to escape when the coagulation is complete.[y] Galvanism and oxygen gas raise its temperature and hasten coagulation, while carbonic acid gas, azote, and hydrogen, have the opposite effects.

The coagulation of the blood is ascribed by J. Hunter to its life:[z] by Mr. Thackrah,[a] on the contrary, to its death, as the separation of a portion from the mass, by escape from a vessel, is

[s] Magendie, *Journal de Physiologie*, t. i., and l. c. t. ii. p. 260.

[t] Vogel, *Annales de Chimie*, t. xciii.

[u] Professor Brande, *Phil. Trans.* 1818. p. 181.

[x] *Phil. Trans.* 1820. p. 6. *An Essay on the Blood*, p. 107. By C. Scudamore, M.D. F.R.S. 1824.

[y] Scudamore, l. c.

[z] *A Treatise on the Blood*, &c.

[a] *An Enquiry into the Nature and Property of the Blood.* By C. Turner Thackrah. London, 1819.

likely to kill it if alive; as every change likely to impair life promotes coagulation, for example, debility, fainting; and as blood frozen, and therefore likely to be killed if alive, and again thawed, instantly coagulates. But the coagulation appears, in most instances, if Dr. Scudamore's experiments be accurate, though others have not found the same results[b], attributable merely to the escape of carbonic acid: and as coagulated blood or fibrine (and the coagulated part of effused blood is fibrine) becomes vascular, one can hardly, if the fluid is alive, regard a coagulum as necessarily dead. See also Sect. VI. Note B.

Large quantities of blood are found fluid in every dead body, showing that simple loss of vitality is not sufficient to cause coagulation. Indeed, the blood of the heart and vessels is found, most frequently, in opposite states, fluid in one part, coagulated in another, yet it is all equally dead. From all these contradictory circumstances, I regard the coagulation of the blood as quite unconnected with its vitality or lifelessness, and as entirely a chemical result. That it, however, is influenced by the vital properties of the containing vessels is possible, but these may operate upon the blood, in this respect, as a mere chemical compound; and even if it be alive, and they influence its life, still the influence, as far as respects coagulation, may in effect be chemical.

The blood generally coagulates in the living body on escaping from its vessels, and even in its vessels if its motion be prevented by ligatures; and when it does not, its subsequent escape from the body almost always produces instant coagulation.[c] It almost always coagulates also in the vessels running through healthy parts to others in a state of mortification, and in large vessels adjoining a pulmonary abscess; in which cases, the final cause — prevention of hæmorrhage, is evident. The efficient cause, however, in all these examples is unknown. In all, the blood is still in contact with living parts: in the two last, it is not at rest till it coagulates. J. Hunter, after mentioning that after a mortification of the foot and leg he found the crural and iliac arteries completely filled with strongly coagulated blood, adds, that this could not have arisen from rest, because the same thing ought then to happen in amputation, or in any case where the larger vessels are tied up.[d] Besides, coagulation after extravasation, or when a

[b] Dr. Turner, *Elements of Chemistry*, 1827. p. 638.

[c] J. Hunter mentions the coagulation of blood let out from the tunica vaginalis, in which it had lain fluid sixty-five days after a wound. *On the Blood*, p. 25.

[d] l. c. p. 23.

quantity is included in a vessel between two ligatures, is not an invariable occurrence.

These facts, in addition to those stated above, show that fluidity or coagulation is not dependent on the simple presence or absence of vitality. Whatever connection coagulation out of the body may have with the escape of carbonic acid gas, there is no proof of it in the case of internal coagulation. Some have thought that heat is evolved during its coagulation[e]; others have denied this.[f] The latest experimenter supports the opinion.[g]

(E) To suppose any affinity of the red particles for either the lymph or the serum is erroneous. Leeuwenhoek and Hartsoeker long since proved that serum merely suspends them, for if, when separated, they are triturated in some serum, part of them is taken up and the serum assumes a red colour; but, if the fluid is allowed to settle in a cylindrical glass, they slowly precipitate themselves to the bottom, and the serum above becomes clear as before. When blood is drawn, the *serum* easily separates on the coagulation of the lymph. But the *lymph* coagulates before the colouring particles have time to fall to the bottom, and entangling them acquires a red colour, forming the crassamentum: if, however, the lymph coagulate slowly, and is thinner[h], as in the phlogistic diathesis and pregnancy, the greater specific gravity of the cruor detaches it very considerably from the lymph, which remains colourless above, constituting what is called the inflammatory coat, crust, or buff. Berzelius even believes the lymph to be in a state of solution in the serum, while the cruor is simply suspended in this solution. In the phlogistic diathesis both the fibrin and the serum are more abundant, and the blood lighter.[i]

Thinness of the blood and a disposition to slow coagulation generally co-exist. But the rapidity of the stream greatly affects the rate of coagulation, so that one portion of the same blood coagulates slowly that is drawn quickly, and another quickly that is drawn slowly.

The appearance of the buffy coat does not arise from the slow coagulation, though increased by it; because, of two portions of the same blood, one has afforded no buffy coat, although it

[e] Dr. Gordon, *Annals of Philosophy*, vol. iv.

[f] Dr. J Davy, *Journal of Science and Arts*, No. iv.

[g] Scudamore, l. c. p. 68. sqq.

[h] Hewson, *Experimental Enquiries into the Blood and the Lymphatic System*, P. I. p. 45. sq.

[i] Scudamore, l. c.

remained fluid at least ten minutes after the buffy coat began to be formed on the other;[k] proving, too, if the buffy coat arise from thinness of the fibrin, as appears from Mr. Hewson's experiments, the red particles continuing of their usual weight, that slow coagulation is not altogether dependent on mere thinness of the blood, though generally connected and proportional with it. Yet rapid coagulation, by means of a slow stream when the blood is thin, may prevent the buffy coat, by not allowing time for the difference in the weight of the fibrin and red particles to have effect. Stirring such blood has the same consequence, and the slower the coagulation of thin blood, occasioned, for instance, by rapid bleeding, the greater will be the buffy coat.

The different cups of blood drawn in an inflammatory disease may vary as to the buffy coat, according to accidental variations in the stream, but generally it is the first cup that abounds in buff, and the last frequently has none. This occurs when there is no difference in the stream.[l] Therefore, if the buff arise from thinness of the fibrin, we must conclude with Hewson[m] that its qualities may be changed even during bleeding. Dr. Scudamore finds much more fibrin in buffy blood; and, consequently, that not merely the thinness, as Hewson found, but the quantity, of fibrin, may vary during the flow of blood.[n]

The greater the strength of the patient and the intensity of the inflammation, the firmer is the coagulum of fibrin and the more cupped its appearance.

Dr. Scudamore did not find a buffy coat in blood drawn immediately after violent exercise.

The blood of different brutes coagulates in different times. Mr. Thackrah imagines the rapidity to be inversely as the strength and size. Thus, while in health, human blood coagulates in from 3 or 4 to 7 minutes, that of the

Horse, in from	2 to 15
Ox,	2 to 10
Dog,	½ to 3
Sheep, hog, rabbit,	½ to 1½
Lamb,	½ to 1
Fowls,	½ to 1½

Mice, in a moment,

Fish, according to Hunter[o], also in a moment.

[k] Hewson, l.c. p. 90. [l] l. c. p. 52. sqq. [m] l. c. p. 56. sqq.
[n] l. c. p. 96. [o] l. c. p. 211.

(F) The coagulable part of serum is albumen; that which remains fluid is called serosity, — a name given it by Cullen, and contains no gelatin as the French chemists asserted, but an animal matter different from both gelatin and albumen, with a minute portion of albumen and fibrin, and affords a little free soda, muriate, lactate[p], and phosphate, of soda, and muriate of potash, with $\frac{905}{1000}$ of water.[q]

If mixed with six parts of cold water, serum does not coagulate by heat.

Under the influence of the galvanic pile, the soda collects at the negative wire, and the albumen coagulates at the positive.

(G) When *venous* blood acquires a florid colour by exposure to oxygen or atmospheric air (and it does so even when covered by a bladder, provided this is moistened[r]), carbonic acid gas is formed, and an equal volume of oxygen gas disappears. If exposed to nitrous oxide, it becomes of a brighter purple, and much of the gas is absorbed: carbonic acid gas renders it darker and is a little absorbed: nitrogen and hydrogen have the same effect. The dark colour produced in arterial blood by carbonic acid or azotic gas takes place if blood is placed in vacuo, though less rapidly and deeply than if exposed to hydrogen gas. Arterial blood left in contact with oxygen gradually acquires the same dark colour, and no oxygen will afterwards render it scarlet. Berzelius finds the colouring particles only concerned in these changes: and, after all, no difference of composition can be detected between scarlet and purple blood. But Prevost and Dumas found more particles, *i. e.* fibrin and red particles, in arterial than in venous blood.

It has been generally supposed that iron exists in the red particles of the blood as a subphosphate. Berzelius informs us that serum, although able to dissolve a small portion of the oxides, not indeed of the phosphates, of iron, does not acquire a red colour by their addition, and that he has never discovered iron

[p] Berzelius discovers lactic acid, free or combined, in all animal fluids. It was first noticed by Scheele, but is generally regarded as a combination of acetic acid with animal matter, and so now even by Berzelius himself.

[q] See Dr. Bostock's papers in the first, second, and fourth volumes of *The Medico-Chirurgical Transactions*, and Berzelius's in the third.

[r] A layer of serum or milk does not prevent this change of colour, while a layer of water or oil does. Dr. Priestley, *Experiments and Observations on different kinds of Air*, vol. iii. p. 78. sqq.

nor lime in the entire blood, although both are so abundant in its ashes. He concludes that the blood contains the *elements* of phosphate of iron and of lime, and of carbonate of lime, and also of phosphate of magnesia, united in a manner different from their combination in the salts. But Dr. Engelhart has lately shown iron to exist in blood, by the usual liquid tests, after passing a stream of chlorin through a solution of red particles.[l]

Mr. Hewson asserted that the particles consist of a nucleus and an enveloping coloured portion.[m] The nucleus is said to be colourless; perhaps about $\frac{1}{5000}$ of an inch in diameter, and the whole globule nearly one-fourth larger.[n] MM. Prevost and Dumas believe,[o] that the internal portion is spherical, but the outer or vesicular, as Hewson noticed[p], flattened. The inner part, according to these enquirers, rolls in the outer, and, in the frog's web and bat's wing, at least, the whole particle is carried, steadily balanced, in the current of blood, sometimes flat, sometimes oblique, sometimes gently turning upon itself; and lengthening if driven into a vessel of diameter hardly sufficient for its admission: the assertion of Reichel, (12. note,) being thus corroborated. Mr. Bauer has discovered a third set of smaller colourless globules in the blood, $\frac{1}{2800}$ of an inch in diameter. They appear to belong to the fibrin, and are accordingly denominated lymph globules. It is thought probable that the central globule of the red particles is the same, and thus really fibrin. Colourless globules gradually form also in serum.[q]

[l] *Edinburgh Medical and Surgical Journal*, Jan. 1827. Engelhart's Essay obtained the prize at Gottingen in 1825.

[m] *Experimental Inquiries*, part 3. p. 16. 1777.

[n] On these measurements consult *Phil. Trans.* 1818. Dr. Young's *Medical Literature*, p. 571. sqq. Prevost and Dumas, *Annales de Chimie*, Nov. 1821.

[o] l. c.

[p] l. c. p. 8. sq. Hewson says, that dilution with water, or a change towards putrefaction, makes the vesicles globular, and that farther putrefaction breaks them down.

[q] *Phil. Trans.* 1819. p. 2. sq. The globules of pus also are maintained to form gradually, and it to be originally an homogeneous fluid. The globules of milk, healthy pus, and chyle, in different animals, are said by Prevost and Dumas to be of the same form and dimensions; and likewise those of the muscular fibre, and of albumen, when coagulated, for particles are not previously seen in it. But Dr. Hodgkin finds the particles of pus to be quite irregular in size and figure, and those of milk, though globules, to be some twice, some only one tenth, the size of the particles of the blood. *Phil. Mag.* Aug. 1827.

It was mentioned in the note to Section I. that Dr. Hodgkin and Mr. Lister had lately employed a microscope superior to those of former investigators, and disproved the opinion of the globular composition of living structures. They, at the same time, examined the blood, and though, like Hewson, they found its particles flat and circular, and indeed with edges somewhat raised, so that the middle of each surface was depressed, they could detect no central particle; and satisfied themselves that the diameter was pretty exactly $\frac{1}{5000}$ of an inch.

(H) Oxygen and hydrogen also exist in fibrin. The fibrin, albumen, and colouring matter, afford, on decomposition, the same saline and gaseous products. Berzelius views them all three as modifications of the same substance. Albumen contains a greater proportion of oxygen than fibrin, and has sulphur for a constituent part, which, however, cannot be detected while the albumen is entire, any more than the iron while the cruor is entire. The chief differences between the colouring matter and fibrin are, colour; the spontaneous coagulation of fibrin at all temperatures, while the colouring matter may be dried without losing its solubility in water, and becomes insoluble only at a certain temperature; and the peculiarity in the latter of not diminishing in volume like fibrin during exsiccation. Albumen is intermediate between the two, and its only character of distinction from fibrin is, that it does not coagulate spontaneously, but requires a high temperature or some chemical agent.

The crystalline lens is a sort of albumen; the epidermis, nails, hair, horn, cartilage, are nearly composed of it; of bone and muscle it is an èssential part. Fibrin exists in muscles only, besides the blood, and is indeed their chief constituent, giving them form, and rendering them fibrous. Gelatine, or rather what becomes so by the agency of boiling water, contains somewhat less carbon and more hydrogen and oxygen than albumen, and although not obtained from blood, is an important part of our frame: the cutis, serous membranes, and tendons, are a species of it; it forms the chief part of cellular membrane, and is an essential constituent of bones, muscles, ligaments, hair, &c. The composition of the substance of the viscera is not well known.[r]

[r] The following results are given in the *Recherches Physico-Chimiques*, (t.ii.) by Gay Lussac and Thenard:

The blood of brutes has the same general character as our own, and Rouelle obtained the same ingredients, though in different proportions, from the blood of a great variety of them. Berzelius finds a larger proportion of nitrogen in that of the ox, and analogy would lead us to suppose there is a peculiarity in the blood of every species. Muscles look pretty much alike in various animals, yet when cooked they disclose the greatest diversities. Transfusion, or pouring the blood of one system into another, satisfies us, that the blood, whether arterial or venous, of one *individual*, agrees well enough with another of the same species; but some late experiments of Dr. Leacock,[s] and subsequently of Dr. Blundel,[t] render it unlikely, contrary to the opinion of former experimentalists, that the blood of one *species* suits the system of another. Dr. Young found the large outer globules of the skate to be somewhat almond-shaped, and Hewson found them of different shapes in different animals, and Rudolphi observed them to be more or less oval in the common fowl and many amphibia.[u] MM. Prevost and Dumas have noticed, in their microscopic experiments, a great difference in the blood of different animals as to the globules, and in this way explain the impossibility of transfusing the blood of some animals to others without danger to life. They assert that the quantity of the particles is proportionate to the temperature of the animal, and that, con-

---

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Gelatin,	47.881	7.914	27.207	16.998
Albumen,	52.883	7.540	23.872	15.705
Fibrin,	53 360	7.021	19.685	19.934

Besides these constituents, they, as well as the colouring matter of the blood, contain a very minute portion of the earthy phosphates.

Fibrin is inodorous and tasteless, whitish, insoluble in water, alcohol, and acids; and, as already said, coagulates when separated from the body.

Albumen is inodorous, tasteless and colourless, and soluble in water, and coagulates by a certain temperature, by the mineral acids, tan, and many metallic salts, especially by corrosive sublimate, and by prussiate of potass, if a little dilute acid is previously mixed with it.

Gelatin is inodorous and tasteless, dries into glue, is soluble in warm water, and becomes solid again on cooling, and dissolves in acids and alkalies.

For minute chemical particulars, however, respecting the nature of the solids and fluids, I must refer the reader to works professedly chemical.

[s] *Medico-Chirurgical Journal*, 1817, p. 276.

[t] *Medico-Chirurgical Transactions*, 1818.

[u] *Grundriss der Physiologie*, 159.

sequently, most exist in the blood of birds: that the size and shape also vary, although the size of the central portion is the same in animals in which they are spherical, and is about $\frac{1}{7500}$ of an inch in diameter; and that the shape of the external part is circular in the mammalia, and elliptical in birds and cold-blooded animals, thus confirming and generalising the observations of others[x], (and this is again confirmed by Dr. Hodgkin) and the shape of the central portion correspondent with that of the external, — spherical when the latter is circular, oval when elliptical. They found, that if the blood of two animals of different species, the blood of one of which was transfused into the other, differed in the size only of the globules, temporary restoration of energy took place; but that if it differed in their shape, convulsions and death were the result. They also find a larger proportion of fibrin and red globules in warm than in cold-blooded animals, and a larger in the former according to the height of the temperature — (of 10,000 parts by weight; in pigeons, 1557; man, 1292; frogs, 690): — a smaller also, accordingly as animals are bled; it thus appearing that bleeding promotes the absorption of watery fluid.[y] The colour of the particles differs in different animals: hence red and white-blooded animals.

Hewson[z] saw the red particles of the blood of the fœtal chicken and viper larger than those of the adult animal: and Prevost and Dumas have observed the red particles of the fœtal goat to be as large again as those of the adult; and those of the chicken to be circular, till about the sixth day, when some elliptic ones are first seen; and on the ninth, from their progressive multiplication, none but elliptic ones can be detected.[a]

The blood of invertebral animals is colourless, but has not been analysed.

The sap of vegetables corresponds to the blood of animals, but is totally different; is nearly as liquid as water; has always an acid, sometimes free, more commonly united with lime and potash. It has various vegetable principles; but sugar and mucilage are

[x] Hewson observed the difference of their size in different animals, and that this bore no relation to the difference in the size of the animal. l. c. part iii. p. 10. sqq.

[y] *Annales de Chimie*, t. xviii. xxiii. 1821 and 1823.

[z] l. c. part iii. p. 39.

[a] *Annales des Sciences Naturelles*, 1824, 1825.

the most remarkable. Sometimes it contains albumen, tannin, and gluten.

It soon effervesces if left alone, and grows sour, or even vinous, if much sugar be present.

About forty years after the discovery of the circulation of the blood, transfusion was practised upon brutes, and at length upon the human subject, though some contend that the operation was known to the ancients. Experiments were made upon the effects of injecting medicated liquids into the blood, first by Wahrendorf, in Germany. It was ascertained that they exert their specific powers exactly as when swallowed, — cathartics, *v. c.* purging, and emetics emptying the stomach. Among other liquids, Dr. Christopher Wren proposed that blood should be injected, and Dr. Lower first put this into practice. It was found that if an animal was drained of its blood, and lay faint and almost lifeless, and the blood of another was transfused into its circulating system it soon revived, stood up, and presently ran about as before, apparently none the worse for the operation. If too much was poured in, the animal became drowsy, breathed with difficulty, and died of plethora. An idea of curing diseases in this way, by substituting the blood of the healthy for that of the diseased, was immediately entertained when the possibility of the operation was proved.

But the first case of human transfusion proved fatal, and the unfortunate results of some careless trials caused the Pope and the King of France to prohibit the practice.

The extravagant hopes of curing diseases and restoring youth, at first entertained in France, were disappointed, and the operation fell into complete neglect, notwithstanding that Denys, in France, was declared to have made a fool clever by a supply of lamb's blood; a Mr. Cox, in England to have cured an old mongrel of the mange with the blood of a young spaniel; and a M. Gayant to have made a blind old dog frisk with juvenile bound which before could hardly stir; till Dr. Leacock brought it again into notice a few years ago, and Dr. Blundel prosecuted this gentleman's researches. Dr. Blundel conceived it might be rationally expected to be of benefit in cases of dangerous hæmorrhage, and he soon proved it to be void of danger in the human subject, if properly performed. Many women who would probably otherwise have perished from uterine hæmorrhage, now owe their lives to his disinterested zeal in establishing the practice.

I should think it applicable to many cases of exhaustion, besides those arising from hæmorrhage. The original history of transfusion will be found in the early numbers of the *Philosophical Transactions:* the successful cases of its employment as a remedy, in the late English journals. The double pump employed for emptying the stomach, or a common syringe, capable of holding four or six ounces, answers very well. But Dr. Blundel at present, when he has able assistants, sometimes receives the blood from the blood-vessel into a funnel, the tube of which is very long, and inserted into the vein of the subject supplied, so that the blood enters by its gravity only.

SECT. III.

OF THE SOLIDS IN GENERAL, AND OF THE MUCOUS WEB IN PARTICULAR.

17. THE solids [a] are derived from the fluids. In the first rudiments of the gelatinous embryo, they gradually commence in their respective situations, and differ infinitely in their degrees [b] of cohesion, from the soft and almost pulpy medullary matter of the brain, to the vitreous substance of the corona of the teeth.

18. Besides the gelatinous (11) and glutinous (14) parts of the solids, earth enters more or less into their composition, and is principally lime united with phosphoric acid, whence it is commonly termed phosphate of lime. The bones possess this in the greatest abundance, particularly in advanced age: whereas in childhood the gelatinous matter abounds.

19. With respect to texture, the majority of the similar parts of the body, as the ancients called them, [c] consist of *fibres* more or less parallel. This may be observed in the bones, especially of fœtuses,[d] in the muscles, tendons, liga-

[a] Hier. Dav. Gaubius, *Spec. exhibens ideam generalem solidarum c. h. partium.* Lugd. Bat. 1725. 4to.

[b] Abr. Kaau Boerhaave, on the cohesion of the solids in the animal body, *Nov. Comm. Acad. Petropolit.* t. iv. p. 343. sq.

[c] They divided the human body into *similar*, or homogeneous parts,—those consisting of particles similar to one another, as the bones, cartilages, muscles, tendons, &c. ; and *dissimilar*, — those composed of the similar, as the head, trunk, limbs, &c.

[d] The parallel and reticulated bony fibres are most striking in the radiated margins of the flat bones, as we find these in new-born heads much enlarged by hydrocephalus. I have, in my anatomical museum, a preparation of this kind, where, in the sphenoid angles of the parietal bones the fibres are an inch or two in length, distinct, and very delicate. The hardest parts of the skeleton, — the bony and vitreous portions of the teeth, exhibit a structure similar to that which in the zeolite, malachite, hematite, &c., all mineralogists call *fibrous*.

ments, aponeuroses, and in certain membranes, as the dura mater, &c.

20. In other parts no fibres can be discovered, but the texture is peculiar, has been called *parenchyma* from the time of Erasistratus, and differs in different viscera, especially the secreting, — of one kind in the liver, for example, and of another in the kidneys.

21. But in all these structures, whether fibrous or parenchymatous, there is interwoven a general *mucous web*, [e] commonly styled cellular, but improperly, because it rather is continuous, equal, tenacious, ductile, sub-pellucid, and glutinous. [f] By handling, it is easily converted into a cellular and vesicular membrane, and demands a place among the most important and remarkable constituents of the body. (A)

22. For, in the first place, many solid parts, *v. c.* most membranes and cartilages, may, by long-continued maceration, be resolved into it alone. With some it is so intimately united, as to afford a receptacle and support for other constituents: *v. c.* the hardest bones consisted at first of cartilage, which itself was a dense mucous web originally, though subsequently distended by the effusion of bony matter into its substance, and rendered more lax and cellular. In fact, it is universally present in the solids, if we except the epidermis, nails, hairs, and the vitreous exterior of the corona of the teeth, in which I have never been able to discover it by employing the strongest acid.

23. To the muscles and membranes especially it serves for separation from other parts; to the vessels and nerves especially for support; and to every part it acts as the common medium of connection.

24. From these facts, two inferences may be drawn.

First: That this membrane is so fundamental a constituent

[e] Dav. Chr. Schobinger, (Præs. Hallero) *De telæ Cellulosæ in fabrica. c. h. dignitate.* Gotting. 1748. 4to.

Sam. Chr. Lucæ at the end of his *Observ. circa nervos arterias adeuntes.* Francof. 1810. 4to.

[f] Casp. Fr. Wolff, *Nov. Act. Petropol.* t. vi. p. 259.

of our structure, that, were every other part removed, and it to retain its position, the body would still preserve its form.

Secondly: That it forms a connection and sort of passage between all parts of the system, however different from each other in nature, or remote in situation: — a circumstance worthy of attention, as putting an end to the verbal disputes respecting the continuation of membranes, and affording an explanation of many morbid phenomena.

25. As most of the solids owe their existence to this membrane, so again its origin is derived from the lymph of the blood, for I have seen lymph transuded on the surface of inflamed lungs, and changed into this mucous web, which, by forming false membranes, unites these organs to the pleura.

26. We shall now consider some varieties of this membrane.

First: its strength is not the same in every part.

In general, it is more *delicate*, cæteris paribus, in *man* than in brutes, — a distinguishing prerogative, by which our sense is rendered more delicate, and our motions and other functions more perfect. [g]

Among different individuals, it varies much in laxity and firmness, according to age, sex, temperament, mode of life, climate, &c.

Finally, it varies in different parts; — more lax in the palpebræ and præputium, and behind the frænum of the tongue; less so around the ears.

27. Besides the purposes before mentioned (22, 23,) it is destined for the reception of several kinds of fluids.

Its chief use in this respect is to receive the serous halitus which moistens and lubricates every part. This, when formed by the blood vessels, it imbibes like a sponge, and delivers over to the lymphatics, thus constituting the grand connection between these two systems of vessels.

27. In certain parts its office is to contain peculiar fluids; *v. c.* in the eye, existing as the vitreous membrane, it contains the vitreous humour:

[g] I have treated this point at large in my work, *De Generis Humani varietate nativa*, p. 46. edit. 3.

In the bones, as the medullary membrane (improperly denominated internal periosteum), the marrow:

In soft parts, it is in great abundance, and contains the rest of the fat, of which we shall speak hereafter. (B)

NOTES.

(A) Since this structure neither secretes mucus, nor consists of mucus, but chiefly of what becomes gelatin by the operation of boiling water, the generally-received appellation of *cellular membrane* appears preferable to that of *mucous tela* adopted by Blumenbach from Bordeu,[h] and especially in this work, as our author (40) suggests the title of *vis cellulosa* for the contractile power of the membrane.

(B) Dr. William Hunter contended that the fat is not contained in the same cells of the cellular membrane as the fluid of anasarca, but in distinct vesicles: because,—1. The marrow, which strongly resembles fat, is contained in vesicles or bags; 2. Parts which are most loaded in anasarca, as the eyelids, never contain fat; 3. In dropsical subjects, exhausted of the fat, the membrane which contained fat appears still very different from the other,—that immediately under the skin, for example, being thin and collapsed, while that opposite the tendon of the latissimus dorsi is thick and gelatinous; 4. Parts which become filled with fluid from gravitation in dropsy, as the penis and scrotum, never contain a drop of oil in the fattest persons; 5. Dropsical parts pit on pressure; the fluid disperses, and returns when the pressure is resumed. This is not the case with parts distended by fat, although it is when oil is poured into the common cellular membrane after death.[i]

[h] *Recherches sur le Tissu Muqueux.*

[i] *Medical Observations and Inquiries,* vol. ii. p. 33. sqq.

CHAP. IV.

OF THE VITAL POWERS IN GENERAL, AND PARTICULARLY OF CONTRACTILITY.

29. Hitherto we have spoken of the solids as the constituents of the system; we now shall view them as endowed with *vitality*, — capable of receiving the agency of stimuli, and of performing motions.

30. Although vitality [a] is one of those subjects which are more easily known than defined, and usually, indeed, rendered obscure rather than illustrated by an attempt at definition, its effects are sufficiently manifest and ascribable to peculiar *powers* only. The epithet *vital* is given to these powers, because on them so much depend both the actions of the whole body during life and those which remain in some parts for a short time after death, that they are not referable to any qualities merely physical, chemical, or mechanical.

31. The latter qualities, however, are of great importance in our economy. For instance, by physical powers, dependent on the density and figure of the humours of the eye, the rays of light are refracted to the axis; by mechanical, the epiglottis is elastic; by chemical affinity, the changes of respiration are effected. But the perfect difference of these *dead powers* from those which we are now about to examine, is evident on the slightest comparison of an organised eco-

[a] A host of authors on the vital powers will be found in Fr. Hildebrandt, *Lehrbuch der Physiologie*, p. 54. sq. edit. 2. 1809. To whom we may add a few of a large number, G. R. Treviranus, *Biologie, Oder Philosophie der lebenden Natur*, vol. i. Gött. 1802. E. Bartels, *Systemat. Entwurf einer allgemeinen Biologie.* Franckfort. 1808. J. B. P. A. Lamarck, *Philosophie Zoologique.* Paris, 1809. 2 vols. 8vo. Bern. Fr. Sverman, or. *de iis quæ cum veteres tum recentiores, imprimis Batavi et Germani, de vitæ corporeæ principio philosophati sunt.* Harderv. 1810. 4to.

nomy with any inorganic body, in which these inanimate powers are equally strong.

32. Indeed, the energy and strength of the *vital powers* are most conspicuously manifested by their resistance and superiority to the others; *v. c.* during life, they so strongly oppose the chemical affinities which induce putrefaction, that Stahl and his followers referred their notion of life to this antiseptic property;[b] they so far exceed the force of gravity, that, according to the celebrated problem of Borelli, a dead muscle would be broken asunder by the very same weight, which it could easily raise if alive, &c.

33. As, on the one hand, the vital properties are completely different from the properties of dead matter, so, on the other, they must be carefully distinguished from the *mental faculties*, which will form the subject of the next chapter: between them, however, there exists an intimate and various relation, observable in many phenomena, but especially in the diversity of temperament.

34. The vital energy is the very basis of physiology, and has therefore been always noticed, though under different *appellations*. The titles of impetum faciens, innate heat, archæus, vital spirit, brute life, head of the nervous system, active thinking principle, vital tonic attraction, have been bestowed upon it by different authors.

35. Nor has there been less variety in the *notions* and definitions to which it has given rise; though in this one point all have agreed, — that its nature and causes are most obscure.

36. As to the question so long agitated by physiologists, — whether the diversity of the phenomena exhibited in the similar parts of the living solid is to be attributed to modifications only, or to distinct species, of the vital energy, we think it best to establish *distinct orders of the vital powers*,

[b] "Life is formally nothing more than the preservation of the body in mixture, corruptible indeed, but without the occurrence of corruption." STAHL.

"What we call life is opposite to putridity." J. JUNKER.

according to the variety of phenomena by which they are manifested.

37. These phenomena are threefold. — Organic *formation* and increase; *motion* in the parts when formed; *sensation* from the motion of certain similar parts.

38. The first requisite involved in the name and notion of an organised body, is a determinate *form* designed for certain ends. That species, therefore, of the vital powers is most general, which produces the genital and nutritive fluids and prepares them for organic nature, and which we have denominated the *nisus formativus*, since it is the source of all generation, nutrition, and reproduction, in each organised kingdom.

39. Those vital powers which are manifested by *motion*, (37) properly so called, in parts already formed, may be divided into common and proper. The *common* are those belonging to similar parts which are widely distributed: *v. c.* contractility to the mucous web; irritability to the muscular fibre. The *proper* are those possessed by some singular organs only, for the purpose of peculiar and anomalous motions.

40. *Contractility* is as generally distributed as the mucous web, which it may be said to animate; and therefore would perhaps not improperly be called the *vis cellulosa*. It is characterised by a simple and not very perceptible effort of the mucous web to contract and react upon its contents, especially upon its source of moisture, — the serous vapour, and to propel this into the lymphatic system.[c]

41. *Irritability*, we mean the irritability of Haller, is peculiar to the muscles, and may, therefore, be called the *vis muscularis*. It is marked by an oscillatory or tremulous motion, distinguished from the action of simple contractility, both by occurring far more easily on the application of any pretty

[c] That Haller and Theoph. de Bordeu — the chief writers on the mucous tela, did not form a just conception of this vital power, is evident from the latter's *Recherches sur le Tissu Muqueux*. Par. 1767. 8vo; and from the dissertation of the former on Irritability, in the *Dictionnaire Encyclopédique d'Yverdun*, t. xxv.

strong stimulus,[d] and by being attended with a much more considerable constriction.

42. Such are the *common* (39) moving vital powers. But some organs differ from the rest so much in their structure, motions, and functions, as not to come under the laws of the common orders of vital powers.

We must, consequently, *either* reform the characters of these orders, institute new ones, and extend their limits; *or*, till this be done, separate these peculiar motions from the common orders, and designate them by the name of *vitæ propriæ*.[e]

As examples may be adduced, the motions of the iris; the erection of the nipple; the motions of the fimbriæ of the Fallopian tubes; the action of the placenta; and of the womb during labour; and probably the greater part of the function of secretion. [f]

43. So much in regard to the vital powers displayed by motion. (37. 39 — 42.)

We have now to speak of *sensibility*, which is peculiar to the nervous medulla communicating with the sensorium. It bears the title of *vis nervea*, and is the cause of perception in the mind when irritation is excited in parts to which it is distributed.[g]

44. The *order* which we have followed in enumerating the vital powers (38—43) is that in which they *successively* arise both during our formation and after birth.

[d] Haller, *De partibus corp. hum. irritabilibus* in the *Nov. Comm. Soc. Reg. Scient. Gotting.* t. iv.

[e] I have spoken of these at large both in my treatise *De iridis motu*, 1784; and my programma *De vi vitali sanguini deneganda*, 1795.

[f] On the vita propria of the absorbent vessels consult Seb. Justin. Brugmans, *De causa Absorptionis per Vasa Lymphatica.* Lugd. Bat. 1795. 8vo.

On the peculiar vital properties of the arteries consult Chr. Kramp, *Kritik der Praktischen Arzneikunde.* Leipzig. 1795. 8vo.

Many of the phenomena now mentioned are ascribed by others to an orgasm, to use an old expression, struggling from the centre to the circumference, and lately designated vital turgor.

[g] Fouquet, *Dictionnaire Encyclopédique de Paris*, t. xv. art. *Sensibilité*.

The nisus formativus must take place before we can ascertain the existence of the new conception.

Then contractility is exerted in the gelatinous substance of the embryo.

When the muscular fibres are produced, they have irritability.

Next, in those few organs whose motions cannot properly be referred either to contractility or irritability, there exists a vita propria.

Finally, after birth, sensibility is superadded.

45. Similar also is the *order*, according to which these vital powers, both common and proper, are distributed to the *organised bodies* of each kingdom.[h]

The formative power must be most universal; without it, indeed, organisation cannot be conceived to exist.

Contractility likewise is common to each kingdom.

Irritability and sensibility, in the sense above explained, are peculiar to animals.

Lastly, the *vita propria* is variously observable in some organs, particularly the generative, both of certain animals and vegetables.

46. It is scarcely necessary to remark that most of these modes of vital energy, though necessarily distinguished into orders, are *intimately* connected; *v. c.* the mucous web, forming the basis of so many organs and the seat of their contractility, is interwoven also with the irritable muscular fibres[i] and the sensible nerves.

47. Whatever may have been the opinions of physiologists respecting the difference or similarity of the vital powers, it is universally agreed that they exist in the similar *solid* parts, as the ancients called them, of which the organs or dissimilar parts are composed.

[h] Consult C. Fr. Kielmeyer, *über die Verhältnisse der organischen Kräfte in der Reihe der verschiedenen Organisationen.* 1793. 8vo.

H. F. Link, *über die Lebenskräfte in naturhistorischer Rücksicht.* Rostock. 1795. 8vo.

[i] See Abildgaard, *Acta Reg. Soc. Med. Havniens.* t. i.

But it has been disputed, and particularly of late, whether vitality is peculiar to the solids, or common also to the *fluids;* and, the latter being granted, whether or no the *blood* only is so endowed.

48. As to the *first* question, the whole natural history of each organic kingdom, as far as it has hitherto been cultivated, abundantly shows that the living parts, however delicate, of all known animals and vegetables, are *solid;* — a circumstance necessarily implied in their determinate figure destined for certain uses. For, not to speak of entire animals (which, however simple, as worms, are, nevertheless, supplied with enveloping membranes), the newly-laid egg, though at first sight merely fluid, on a more careful examination is discovered to consist of different membranes, of the halones, the cicatricula, &c.

Humidity is, indeed, necessary in the living solid for the *exertion* of vitality. But that vitality exists in the solid, as solid, is proved by the well-known instances of animalcules and the seeds of plants, in which, although long dried, the vital principle is so entire, that they again live and germinate.

49. With respect to the supposed exclusive vitality of the *blood,* I candidly confess that no fact has been adduced in its favour since the time of Harvey, which might not, I think, be more easily, simply, and naturally explained on the contrary supposition.

For example, the incorruptibility of the blood during life, is far more explicable by the perpetual changes which it undergoes, especially in respiration.

That the blood is the material from which the living solids are produced, is no stronger an argument of its vitality than the formation of nymphææ, and of so many other remarkable plants, would be for the vitality of river water.

It is difficult to comprehend how the coagulation of the lymph of the blood when drawn from a vein can demonstrate its vitality. The organisation of this lymph in generation, nutrition, and reproduction, depends not upon the lymph itself, as lymph, but upon the action of the nisus formativus (38) upon it.

50. Those who formerly contended that the blood acquires in the lungs from the air a certain principle to be universally distributed during circulation, for the purpose of imparting motion, &c. to the organs, were right, if they regarded that principle (analogous to the *oxygen* of the moderns) as the stimulant of the living solid; wrong, if they regarded it as vitality itself.

51. For it is on all hands agreed, that no motion occurs but upon the action of *stimuli*, to receive which action the vital powers are naturally adapted and intended.

52. These stimuli,[l] however multifarious, are conveniently reduced to three classes; — *chemical*, *mechanical*, and *mental*. For the present, we shall say nothing of their various modes of action, — in some instances direct, — in others indirect, by sympathy and sensorial reaction. It is sufficient at present to cite a few examples of functions, to which each class of stimuli conspires; such is the increased secretion of tears, saliva, bile, &c. and the venereal turgescence of the genitals.

53. If the nature of stimuli is infinitely various, no less so are their *effects*, according to their nature, intensity, or continued and repeated application to the living solid. Hence they are generally divided into *exciting* and *depressing*.

54. The power of certain stimuli in increasing the effects of others, is very remarkable: v.c. the power of caloric, upon which probably national temperament chiefly depends.[m] That of joy, a most energetic mental stimulus, is similar.[n] Like-

[k] v. c. Dan. Bernouilli, *De Respiratione*. Basil. 1721.

" Respiration supplies a very subtle air, which, when intimately mixed with the blood, greatly condensed, conveyed to the moving fibres, and allowed by the animal spirits to exert its powers, inflates, contracts, and moves the muscles, and thus promotes the circulation of fluids and imparts motion to mobile parts."

[l] Laur. Bellini, *De Sanguinis Missione*, p. 165. 183.
Sylvest. Douglas, *De Stimulis*. Lugd. Bat. 1766.

[m] Montesquieu, *De l'Esprit des Lois*, t. ii. p. 34. London. 1757. 8vo.

[n] J. Casp. Hirzel, *De Animi læti et erecti efficacia in corpore sano et ægro*. Lugd. Bat. 1746.

wise perhaps that of oxygen, (50) by whose chemical stimulus the vital powers, particularly irritability, are greatly excited, and more disposed to react upon the impulse of other stimuli.

55. Not less considerable than the variety of stimuli, is that *more minute* discrepancy of the different organs, and of the same organs in different individuals, according to age, sex, temperament, idiosyncrasy, habit, mode of life, &c., to which are owing the diversified effects of the same stimuli upon different organs of the same body,[o] and even upon the same in different individuals, and upon which depends what the English have lately termed *specific irritability*.[p]

56. Lastly, the influence of stimuli by means of *sympathy*, is very extraordinary: by its means, if one part is excited, another, frequently very remote, consents in feeling, motion, or some peculiar function.[q]

The primary and most extensive cause of sympathy must be referred to the *nerves*,[r] and indeed chiefly to the *sensorial reaction*;[s] so that if one nervous portion is excited, the sensorium is affected, which, reacting by means of the nerves on another part, draws it into consent with the first, although there exist between them no immediate nervous connection. Such is the sympathy of the iris, when the retina is stimulated by light; and of the diaphragm during sneezing, when the Schneiderian membrane is irritated.

There are other examples of sympathy, in which the nerves

[o] Called *Le Tact ou le Goût particulier de chaque Partie*, by Theoph. de Bordeu, *Recherches Anatomiques sur les Glandes*, p. 376. sq.

[p] Sam. Farr, *on Animal Motion*. 1771. 8vo. p. 141.

J. Mudge's *Cure for a recent catarrhous Cough*. Edit. 2. 1779. 8vo. p. 238.

Gilb. Blane, *On Muscular Motion*. 1788. 4to. p. 22.

J. L. Gautier, *De irritabilitatis notione, &c.* Hal. 1793. 8vo. p. 56.

[q] J. H. Rahn, *De Causis Physicis Sympathiæ*. Exerc. i. — vii. Tigur. from 1786. 4to.

Sylloge selectiorum opusculor. de mirabili sympathia quæ partes inter diversas c. h. intercedit. Edited by J. C. Tr. Schlegel. Lips. 1787. 8vo.

[r] G. Egger (the author Lawr. Gasser), *De consensu nervorum*. Vindob, 1766. 8vo.

[s] J. G. Zinn's Obzervations on the different Structure of the Human (and brute) Eye. Diss. ii. 1757. *Comment. Soc. Reg. Scient. Gotting. antiquiores*. t. i.

have, if any, but a more remote and accessory share:[t] among these must be placed the sympathy along the *blood vessels*, strikingly instanced, especially in advanced pregnancy, between the internal mammary and epigastric arteries, from their anastomosis; that along the *lymphatic vessels*,[u] also most remarkable during pregnancy and suckling; and again, that dependent on *analogy of structure and function*, v.c. the sympathy of the lungs with the common integuments and intestines. (A)

57. So much with respect to the vital powers in general. They will be hereafter separately considered, under the distinct heads of our subject:

The nisus formativus under the head of Generation;
Irritability under that of the Muscles;
Sensibility under that of the Nervous System;
The *vita propria* whenever occasion requires.

58. Besides our former brief remarks (40) upon *contractility*, a few more minute will at present be very appropriate.

It prevails universally, (40) wherever the mucous tela is discoverable.

It is consequently most abundant in parts, destitute of proper parenchyma, but composed almost entirely of mucous tela, *v.c.* in certain membranes. For no one will deny their contractility, who reflects upon the spastic motions of the dartos, the male urethra, or of the gall bladder, which after death has often been found closely contracted upon any calculi it may contain.

It appears also in those viscera which consist chiefly of this tela, *v.c.* in the lungs, whose external surface we have found

[t] Consider the constant sympathy of heat between certain parts of some animals, *v. c.* of the hairs with the fauces, in variegated rabbits, sheep, dogs, &c.; of the feathers with the covering of the bill and feet in varieties of the domestic duck. That such instances are not referrible to the influence of nerves, I contended by many arguments in my *Comm. de motu iridis*. p. 12. sq.; and also in my work *de generis humani varietate nativa*. p. 364. sq.

[u] Innumerable pathological phenomena will be found explained by this sympathy in S. Th. Soemmerring, *De Morbis Vasorum Absorbentium Diss. quæ præmium retulit*. Francof. 1795. 8vo.

on frequent living dissection very contractile, but by no means, as Varnier asserted, truly irritable. (B)

The presence of contractility, even in the bones, is demonstrated by the shrinking of the alveoli after the loss of the teeth, and by the process of necrosis, by which the new bone, when the dead portion is extricated from its cavity, gradually contracts to its natural size and figure.

The vitreous substance of the teeth, being destitute of this tela (22), possesses no contractility, as I think appears from the circumstance of its not shrinking, like the alveoli, if a portion is separated by caries or fracture.

59. This contractility of the mucous tela (C) is the chief cause of strength, health, and beauty; since on it depend the vital elasticity and fulness,[x] and indeed the *tone*, of parts, so elegantly described by Stahl; for by its means, the mucous tela, to mention one only of its functions, absorbs, during health, the serous fluid (27) like a sponge, and propels it into the lymphatic vessels: in disease, on the contrary, having lost its tone, it is filled with water, giving rise to œdema and similar cachexies.

60. Finally, the great influence of this contractility upon the other vital powers, is manifest from its universal existence, and its effect in producing the peculiar constitution and temperament of individuals; and from its infinite varieties and degrees in different persons.

NOTES.

(A) John Hunter divides sympathy into general and partial; such as pyrexia from a wound, and convulsion of the diaphragm from irritation in the nose. Partial sympathy he subdivides into remote, contiguous, and continuous, — Where there is no evident connection between the sympathising parts, sufficient to account

[x] Hence, after death, even in young subjects full of juices, the back, loins, and buttocks, having for some time lost their vital tone, are, if the body is supine, depressed and flattened by the superincumbent weight, which now is not resisted: this appearance may, therefore, be regarded among *the indubitable signs of death.*

for the circumstance; as vomiting from the pregnant state:— Where there is proximity of the sympathising parts; as tenesmus when a stone exists in the urinary bladder: — and Where, as most commonly, the sympathising parts are continuous; as itching of the nose and verge of the anus from worms in the intestines.[y]

Bichat's division[z] cannot be understood till after the perusal of Note B, Sect. VI. He considers sympathy as affecting either animal sensibility or contractility, as pain of the knee in diseases of the hip, or tetanus from a wound of the extremities; or organic sensibility or contractility, as palpitation from disorder of the stomach.

Sympathy does not arise from mere nervous connection, because it frequently happens that no particular nervous communications of sympathising parts are discoverable, as between the nose or eye and diaphragm, although sneezing follows from a pinch of snuff in the nose or the sun's glare upon the eyes, while remarkable ones exist between other parts not particularly disposed to sympathise, as the neck and diaphragm.[a] Vegetables, which are not known to have nerves, show sympathy: if a leaflet of the sensitive plant is stimulated by a burning-glass, the whole leaf contracts and the foot-stalk drops; when the branches of trees feel the warmth of summer, the sap ascends in the roots; and even in a frost it will ascend from the roots through the stem, if a single branch is introduced into a hot-house.[b]

Sympathy of animal contractility occurs only when the nerves connecting the affected muscles with the brain are entire; when

[y] *Treatise on the Blood, &c.* Introduction.

[z] *Anatomie Générale.* T. i. p. 183. sq.

[a] Consult Dr. Whytt, *Observations on Nervous Diseases*, ch. i.

[b] Sir Gilbert Blane, *Medical Logic.* 3d Edit. p. 154. Some, as M. Dutrochet, have imagined vegetables to have a nervous system, but never shown it. The opinion has been thought proved by the action of certain poisons upon them. We know that they are poisoned like animals; arsenic, mercury, copper, lead, and tin, destroy them, and are found to be taken up by their vessels. Carbonic acid, azote, nitric oxide, hydrogen, when applied to the roots, are equally fatal. Opium, prussic acid, belladonna, nux vomica, menispermis coculus, hemlock, digitalis, alcohol, and oxalic acid, are no less so; and because these destroy the life of animals without leaving chemical traces, and affect the nervous system, M. F. Marcet, whose experiments will be found in the *Annales de Chimie*, June 1825, concludes that they must destroy vegetables by acting on a nervous system in them. But although no trace be discoverable, this may

they were divided by Bichat, the convulsions in the corresponding muscles ceased.

Neither, where sympathetic muscular action arises from a sensation, will it occur, if the nerves communicating impressions from the affected part to the brain are compressed or divided, or if the brain itself is unable to receive the impression: — although the stomach may be thrown into contraction in an animal newly dead, by mechanical irritation, no sympathetic action of the diaphragm and abdominal muscles, no vomiting, occurs[c]; sneezing or contraction of the iris cannot be induced in coma, by stimulating the nostrils or letting the sun's rays into the eye. Even when the impression is not perceived, but the action is of voluntary muscles, as in hiccup, the action ceases if the brain is disqualified for the impression; *v.c.* a forcible distraction of the attention arrests hiccup. The necessity for sighing after reading or listening attentively arises from our forgetting to breathe fully, — not fully perceiving the want of breath while our attention was so occupied[d]; and the general coughing and sneezing in church at a pause in the sermon, is owing to the sensations which give rise to those actions having been for a time overpowered throughout the congregation by other feelings.[e]

The sympathies of the organic functions are not all ascribable, as many might imagine, to continuity of surface; for after dividing the œsophagus of a dog, Bichat produced vomiting equally as before, on irritating the fauces.

Sympathy depends on the peculiarity of the sensation as well as upon the part. " When the sides or soles of the feet are

---

be on account of their chemical peculiarities, (and, in fact, prussic acid and alcohol have been found absorbed, *Annales de Chimie*, Oct. 1814, and Dr. Cooke *on Apoplexy*,) and they, as well as other poisons, affect the nervous system of animals only as one part of the *living* body,—arsenic, besides its general deleterious agency, causing particularly gastritis, even if applied to a sore of the leg, digitalis exciting the kidneys (indeed their action on vegetables, might, on the other hand, be urged as a proof of their *general* hostility to life); and the mineral ones, which often leave chemical traces, also produce peculiar effects on the nervous system, and often destroy life without being detected beyond the alimentary canal.

[c] Whytt, l. c. [d] Darwin, *Zoonomia*.

[e] Dr. Alison's Observations on Sympathy in the *Edinburgh Med. Chirurg. Trans.* vol. ii., in which is ably refuted an attempt by Mr. Charles Bell to explain associated muscular contractions in certain actions by communications of nerves at their roots, in his *Exposition of the Natural System of the Nerves of the Human Body*, 1824.

tickled," says Whytt, "the body is often thrown into convulsive motions; but nothing of this kind happens when those parts are either inflamed or wounded: neither an acrid injection of a solution of corrosive sublimate, nor the introduction of a catheter into the urethra, occasions any alternate convulsive motions of the acceleratores urinæ, although the semen, which stimulates the nerves of the urethra much more gently, has this effect."

The same cause, too, will produce the same sympathetic effect, though applied to different parts. Convulsions arise from tickling any part; nausea from a disgusting smell, taste, or sight.

The same sympathetic effect, lastly, may arise from many different causes in different parts: vomiting may arise from injuries of the head, a stone in the kidney, disgust, sailing, &c.[f]

Sympathy is of the utmost importance in health. When the glans penis is irritated to a certain pitch, not only the ejaculatores seminis, but the levatores ani, are thrown into violent action: when the uterus has arrived at the term of gestation, the breasts secrete milk. Sympathy often occurs, in disease, in parts which showed none during health; as pain of the right shoulder in affections of the liver: and new sympathies occur in parts which were sympathetically connected in health, as vomiting in constipation; pain, and even secretion of milk, in the breasts, when the uterus or ovaria are diseased.

(B) Our author here, as below (135), means the pulmonary portion of the pleura, and very properly regards this and other serous membranes, as condensed cellular substance; that is, as a substance not originally cellular and now condensed, but of the same nature with the cellular membrane, though much more compact.[g]

I may mention that Rudolphi asserts that serous membranes are incapable of inflammation, are not vascular, and do not secrete; but that the secretions of close sacs take place from the subjacent parts, and transude the serous membranes, which are thus regarded only as a kind of cuticle; and he further asserts, that they in a similar way line all the mucous surfaces.[h]

(C) The shrinking of cavities on the removal of the distending cause (58), is referable to mere elasticity; and also, the constant effort (if real) of the cellular membrane to contract upon its contents. (40)

[f] See Alison, l.c.

[g] Consult Bichat, *Traité des Membranes.*

[h] *Grundriss der Physiologie,* 113.

SECT. V.

OF THE MENTAL FACULTIES.

61. MAN, whom we have found possessed of a body, answering completely, both in matter and texture, as well as in vital powers, the purposes of its formation, is endowed likewise with a *mind*, a "divinæ particula auræ," intimately connected with the body, and developing by education and exercise various kinds of faculties, which we shall concisely enumerate, as far as they belong to our subject.[a]

62. The sensibility of the nerves, mentioned above among the vital powers, (43) constitutes, as it were, the medium which propagates the impressions of stimuli upon sensible parts, and especially upon the organs of sense (the functions of each of which we shall hereafter examine), to the sensorial portion of the brain, in such a manner that they are perceived by the mind.

63. The mental faculty to be first enumerated, and indeed to be placed at the bottom of the scale, is the faculty of *perception*, by means of which the mind takes cognisance of impressions made upon the body, and chiefly upon the organs of sense, and becomes furnished with ideas.

64. This faculty is assisted by another of a higher order,—*attention*, which so directs the mind, when excited, to any idea, that it dwells upon that idea alone, and surveys it fully.

65. To preserve and recall the marks of ideas, is the office

[a] Consult Alex. Chrichton, *Inquiry into the Nature and Origin of Mental Derangement, comprehending a concise System of the Physiology and Pathology of the Human Mind.* Lond. 1798. 2 vols. 8vo.

Em. Kant, *Anthropologie in pragmatischer Hinsicht.* Konigsb. 1798. 8vo.

Chr. Meiner, *Untersuchungen über die Denkkräfte und Willenskräfte des Menschen nach Anleitung der Erfahrung.* Gött. 1806. 2 vols. 8vo.

Gottl. E. Schulze, *Psychische Anthropologie.* 2d ed. Gött. 1819. two vols. 8vo.

of *memory* — the part of the mind, that, in the language of Cicero, is the guardian of the rest.

66. *Imagination*,[b] on the contrary, is the faculty of the mind, that represents not merely the signs, but the very images of objects, in the most lively manner, as if they were present before the eyes.

67. *Abstraction* forms general notions more remote from sense.

68. *Judgment* compares and examines the relations both of the ideas of sense and of abstract notions.

69. Lastly *Reason* — the most noble and excellent of all the faculties, draws inferences from the comparisons of the judgment.[c]

70. The combination of these constitutes the *intellectual faculty*. But there is another order, relating to *appetency*, the word being taken in its most extensive meaning.

71. For since we are impelled by various internal stimuli to provide food and other necessaries, and also to satisfy the sexual instinct, and are impelled the more violently, in proportion as we are inflamed by imagination, *desires*, properly so called, are thus produced; and if, on the other hand, the mind becomes weary of unpleasant sensations, *aversions* occur.

72. Finally, that faculty which selects out of many desires and aversions, and can at pleasure determine to perform functions of the body for certain purposes, is denominated *volition*.

73. Our order of enumeration corresponds with that of

[b] The difference, or analogy and relation, of memory and judgment, have given rise to various controversies. Some celebrated psychologists have included both under the word *imagination* taken in its most comprehensive sense, and have divided it into two species; *memory* representing former ideas, and the *facultas fingendi*, representing such ideas only as are formed by abstraction. They again divide memory into *sensitive* (imagination in a stricter sense) and *intellectual*. Their FACULTAS FINGENDI they also subdivide into *intellectual* — the more excellent; and *phantasy* — obeying mechanical laws. Consult Feder, *Grundsätze der Logik und Metaphysik*. Gotting. 1794. p. 20.

[c] Of this the highest prerogative of the human mind, by which man exerts his dominion over other animals, and, indeed, over the whole creation, I have fully treated in my book *De Gen. Hum. Var. Nat.* p. 52. ed. 3.

the developement of the faculties, and with the relation in which those which were first mentioned, — common to man and brutes, and those more or less peculiar to man, stand to each other.

NOTE.

Dr. Gall gives a very different view of the mental faculties. Instead of dividing them into perception, attention, memory, judgment, &c. as fundamental faculties; and viewing "the Power of Taste, a genius for Poetry, for Painting, for Music, for Mathematics," &c. as "more complicated powers or capacities, which are gradually formed by particular habits of study or of business;"[d] he regards these last powers as distinct faculties, and perception, attention, memory, judgment, &c. merely as modes or varieties common to the action of each faculty.[e] He contends that when we see a boy, *brought up exactly like his brothers and sisters*, displaying fine musical talents or an astonishing power of calculation, *though in all other respects a child*, his pre-eminence cannot be explained by particular habits of study or of business, nor by mere strength of judgment, memory, &c.: — That the boy has a strong perception of melody, a strong memory of tunes, a strong musical imagination, a strong musical judgment, or a strong perception, memory, and judgment, of numbers; but is not clearer-headed or more attentive on any other point, while men of the strongest sense may have no perception, memory, or judgment, of tunes, or may calculate with extreme difficulty. It is the same with regard to instinct. Writers consider instinct a general faculty, while it is only the inherent disposition to activity possessed by every faculty, and there are, therefore, as many instincts as fundamental faculties. By instinct "the spider spreads a web and ensnares flies; the working bee constructs cells, but does not kill flies to support itself; it takes care of the young but does not

[d] Dugald Stewart, *Outlines of Moral Philosophy*, p. 10.

[e] *Anatomie et Physiologie du Système Nerveux.* Paris, 1818, 1819.

Sur les Fonctions du Cerveau et sur celles de chacune de ses Parties. 8vo. Paris 1822 — 1825.

copulate. Many male animals copulate, but take no care of their young; the cuckoo, both male and female, abandons the charge of bringing up its young to other birds, although it is compelled to copulation by a very ardent instinct. The castor builds a hut, but neither sings nor hunts; the dog hunts, but does not build; the butcher-bird sings, builds, and preys; the quail does not mate, but copulates, takes care of its young, and migrates; the partridge mates, copulates, and takes care of its young, but does not migrate; the wolf, fox, roebuck, and rabbit, marry, and take care of their young conjointly with the female: the dog, stag, and hare, copulate with the first female they meet, and never know their offspring. The vigorous wolf, the artful and timid hare, do not burrow like the courageous rabbit and the cunning fox. Rabbits live in republics, and place sentinels, which is done by neither the fox nor the hare. How can these various instincts exist in one species of animals and not in another? How can they be combined so differently? If instinct were a single and general faculty, every instinct should show itself, not only at once, but also in the same degree, and yet while in the young animal many instincts act with great force, others are still quite inactive: some instincts act at one season, others at another. There is one season for propagation, another for emigration; one season for living solitarily, another for assembling in companies, and for collecting provisions. And how can we explain, on the supposition of a general instinct, why the different instincts do not exist merely separate in different species of animals, but that many of them are even contradictory?"[f]

For my own part, when I reflect upon the *various* talents and dispositions of persons who are all placed in the *same* circumstances,— how unsuccessfully some apply, with the *utmost perseverance*, to a branch of study, in which another, under the *same* instructors, or, perhaps, *scarcely assisted at all*, or even with every *impediment* thrown in his way, reaches excellence with little trouble, and, again, fails in one in which the first is, on the other hand, *successful*,—how early *various* tempers are developed among children of the *same* nursery,—how *hereditary* are peculiarities of talent and of character,—how *similar* some persons are to each other in one point of talent and character, and *dissimilar* in another,—how positively *contradictory* many points of the *same*

Gall, *Sur es Fonctions du Cerveau*, . vi. p. 415, sqq.

character are found;—how exactly the same is true of all species of brutes, and of all individuals among them,—each species having its peculiar nature, and each individual its peculiar character:—I confess myself unable to deny that there is one innate faculty for numbers, another for colours, a third for music, &c. &c., with a variety of distinct innate sentiments and propensities; and that memory, judgment, &c. are but modes of action common to the different faculties.[g]

The faculties of whose existence Gall has satisfied himself are: 1. The instinct of generation; 2. The love of offspring; 3. The disposition to friendship; 4. Courage; 5. The instinct to destroy life; 6. Cunning; 7. The sentiment of property; 8. Pride; 9. Vanity; 10. Circumspection; 11. Sense of things; 12. Sense of locality, or of the relations of space; 13. Sense of persons; 14. Sense of words; 15. Sense of language; 16. Sense of the relations of colours; 17. Sense of the relations of tones; 18. Sense of the relations of numbers; 19. Sense of construction; 20. Comparative sagacity; 21. Metaphysical sagacity; 22. Wit; 23. Poetic talent; 24. Goodness; 25. Faculty of imitation; 26. Religious feeling; 27. Firmness. He has been long inclined to admit also a sense of order and a sense of time, and waits only for proofs of their organs.

Gall gives various other names to each faculty, more anxious to express his view of the nature of each than to quibble for appellations.

For information respecting the precise nature of each faculty, many of which may be ill understood from their designations, I refer to the latter part of the third, and to the fourth and fifth volumes of Gall's *Fonctions du Cerveau*,—portions of the work which the most indolent will find entertaining.

That the faculties enumerated are not modifications of each other, or of any other, but distinct and primitive, Gall considers proved by the circumstance of each having one or more of the following conditions.

"An instinct, inclination, sentiment, talent, deserves," says he, "the denomination of fundamental, primitive, radical:

"1. When a quality or faculty, (or its organ) is not manifested nor developed, nor diminishes, at the same time with others.

[g] See the poet Cowper's amusing account of the different characters of his three hares. But all persons conversant with horses, dogs, cats, or any other domestic brute, knows that every individual among them is proportionally as different in its various abilities and dispositions, from others of its species, as every human being is from other men.

Thus, the instinct of generation (with its organ) is generally developed and manifested later than other inclinations. Thus, the memory of names usually grows weak sooner than the other faculties.

"2. When, in the same individual, a quality or faculty is more or less active (and its corresponding cerebral part more or less developed) than the others. Thus, the greatest sculptors, painters, designers, have sometimes not the least disposition to music; the greatest poets little talent for mathematics.

"3. When a single quality or faculty is active, whilst the others are paralysed (and only the corresponding organ developed). Thus, persons imbecile in every other respect, are often violently impelled by physical love, or have a great talent for imitation, &c.

"4. When, all the other qualities and faculties being active (and all the other organs sufficiently developed), one single quality or faculty is inactive (and one single organ not developed). Thus, certain individuals cannot comprehend that two and two make four; others detest music, or women.

"5. When, in mental diseases, one quality or faculty only suffers, or one only is entire. Thus, one insane person is mad only in regard to religion, to pride, &c.; another, although mad in every respect, still gives lessons in music with great intelligence.

"6. When the same quality or faculty is quite differently manifested in the two sexes of the same species of animal (and the organ is differently developed in the two). Thus, the love of offspring (with its organ) is more developed in the females of most animals: thus, among singing birds, the male only sings (and has the organ well developed).

"7. Lastly, when the same quality or faculty (and the same organ) always exists in one species and is deficient in another. Thus, many species of birds, the dog, the horse, &c. have no inclination (nor organ) for construction, though so strikingly manifested in other kinds of birds, in the squirrel, in the castor. Thus, certain kinds of animals are predaceous, migrate, sing, take care of their young, while other kinds are frugivorous, lead stationary lives, do not sing, abandon their offspring."[h]

Perception, memory, judgment, &c. are modes of action of these distinct faculties. "As often as there exists a fundamental faculty, a particular and determinate intellectual power, there

[h] l. c. t. iii. p. 213. sqq.

necessarily exists likewise a *perceptive* faculty for objects related to this faculty. As often as this faculty is active upon the objects of its option, there is *attention*. As often as the ideas or traces which the impressions of objects have left in the brain are renewed, either by their presence, or in the absence of these same objects, there is remembrance, reminiscence, *passive memory*. If this same renewal of received impressions takes place by an act of reflection, by a voluntary act of the organs, there is *active memory*. As often as an organ or a fundamental faculty compares and judges the relations of analogous and dissimilar ideas, there is comparison, there is *judgment*. A series of comparisons and judgments constitutes *reasoning*. As often as an organ or a fundamental power creates, by its own inherent energy, without the concurrence of the external world, objects relative to its functions; as often as the organ discovers, by its own activity, the laws of the objects related to it in the external world, there is *imagination*, invention, genius.

"Whether, now, we consider perception, attention, memory, reminiscence, recollection, comparison, judgment, reasoning, imagination, invention, genius, either as gradations of different degrees of the same faculty, or as peculiar modes of being of this faculty, it still remains certain, that all the fundamental faculties which have been demonstrated, are endowed, or may be endowed, with perception, attention, memory, recollection, judgment, imagination; and that, consequently, it is they which ought to be considered intellectual and fundamental faculties, and that the pretended mental faculties of my predecessors are only common attributes. Here, then, is a perfectly new philosophy of the intellectual faculties, founded upon the details of the natural history of the different modifications of human intellect. The same may be said of the appetitive faculties or rather qualities."[1]

"When a person has the talent for music, poetry, construction, judging of distance, &c. in only a weak degree, he will not have a very decided inclination for those objects. If, on the other hand, the organs of these fundamental forces are more energetic, the person feels a pleasure in the exercise of their functions; he has an inclination for these objects. When the action of these organs is still more energetic, he feels a want to occupy himself

[1] l. c. t. vi. p. 405. sqq. See also t. iii. p. 131. sqq.

with them. Lastly, when the action of these organs preponderates, the person is impelled towards these objects; he finds his happiness in them, and feels disappointed, unhappy, when he cannot follow his inclination; he has a passion for these objects. Thus it is that certain individuals have a passion for music, poetry, architecture, travelling," &c.[k]

"'You shall not persuade me however,'" Gall fancies it will be said to him, "'that the faculties acknowledged by philosophers as faculties of the soul, are chimæras. Who will dispute that understanding, will, sensation, attention, comparison, judgment, memory, imagination, desire, liberty, are not real operations of the soul, or, if you please, of the brain?'" "Yes," replies Gall, "without doubt these faculties are real, but they are mere abstractions, generalities, and inapplicable to a minute study of a species, or of individuals. Every man, who is not imbecile, has all these faculties. All men, however, have not the same intellectual or moral character. We must discover faculties, the various distribution of which determines the various species of animals; and the various proportions of which explain the varieties among individuals. All bodies have weight, all have extension, all have impenetrability; but all bodies are not gold or copper, all are not any plant, or any animal. Of what use to the naturalist would be the abstract and general notions of weight, extension, and impenetrability? If we confined ourselves to these abstractions, we should still be in the most profound ignorance of every branch of physics and natural history.

"This is exactly what has happened to philosophers with their generalities. From the most ancient period down to the present day, one has not made a single step farther than another in the precise knowledge of the true nature of man, his inclinations and his talents, or of the source of his motives and determinations. Hence we have as many philosophies as soi-disant philosophers: hence the vacillation and uncertainty of our institutions, especially of those which relate to education and criminal legislation."[l]

Gall does not pretend to have discovered the ultimate nature of *all* the fundamental faculties which he has pointed out. The poet's faculty, for example, he regards as distinct and fundamental, because it has the conditions of a fundamental faculty above

[k] l. c. t. vi. p. 408.

[l] l. c. t. i. p. 49. sq. See also t. vi. p. 392. sqq.

enumerated, but what are the ordinary functions of that part of the brain, which, when greatly developed, produces the poet, he dares not determine. [m]

Neither does Gall pretend to have enumerated all the fundamental faculties of the mind. "Probably," says he, "those who follow me in the career which I have opened, will discover some fundamental forces and some organs which have escaped my researches." [n]

He doubts, however, whether so many will be discovered as some apprehend. A modification of a faculty must not be mistaken for a faculty, nor the result of the combined action of several faculties for a particular faculty. "If" he says, "we reflect on the number of possible combinations which may result from the twenty-seven or thirty fundamental faculties or qualities, from the reciprocal action of as many organs, we shall not be surprised at the infinite number of shades of character among mankind. How many different combinations result from the ten ciphers, from the twenty-four letters." [o]

This view of the mental faculties may be considered quite independently of the peculiar doctrines of Gall respecting the cerebral organs of each faculty, and even quite independently of the fact of the brain being the organ of the mind. It may be examined precisely like the metaphysics of Locke, Reid, Stewart, Brown, &c. [p]

[m] l. c. t. v. p. 243.

[n] l.c. t.v. p. 406. Gall's late pupil and assistant, Dr. Spurzheim, thinks he has discovered distinct faculties and organs for conscientiousness and hope, and for judging of weight and size. (*Phrenology, or the Doctrine of the Mind*, by J. Spurzheim, M.D. London, 1825. 3d edit.) In Edinburgh, they think they have discovered a faculty and organ for concentrating the action of the other faculties. (*A System of Phrenology*, by George Combe, 2d ed. Edinb. 1825, and the *Phrenological Journal*, published quarterly at Edinburgh.) They have also an organ for judging of differences, a new portion of brain for the sense of the ludicrous, and make several other refinements, the foundation for which requires much further investigation.

[o] l. c. t. v. p. 406. sq.

[p] It is remarkable, that nearly every one of these faculties has been admitted by one metaphysician or another. See Mr. G. Combe's Letter in reply to Mr. Jeffery, the editor of the *Edinburgh Review*, reprinted in the *Phrenological Journal* of Edinburgh, 1827.

Notwithstanding, too, that memory, like judgment. attention, &c., was considered a distinct and fundamental faculty, some writers taught that there were

It, however, derives its great proofs from the fact of the individual faculties being, cæteris paribus, strong in proportion to the development of particular parts of the brain, as we shall see in Sect. XII.; and these facts suppose the other general fact of the brain being the organ of the mind.

On the subject of paragraph (73), I shall speak in the Note (F), Sect. XLIV.

Every sentiment and propensity was given us for a good purpose, and it is only when one or more are excessive, or defective, or too much or too little excited by external circumstances, or by disease, that error occurs; and on this subject the profound metaphysical sermons, preached at the Rolls Chapel by the exemplary Bishop Butler,[q] and an essay on the constitution of man by Mr. George Combe,[r] highly deserve perusal. The natural tendency of all our united faculties and feelings, the Bishop proves, is to virtue; and Mr. Combe ably and beautifully shows, by numerous illustrations, that obedience to the laws of nature, in strict accordance with phrenology, is the only source of virtue and of the happiness of individuals and nations.

---

three sorts of memory; one for facts (*memoria realis*), one for words (*memoria verbalis*), and one for places (*memoria localis*). See Gall, l. c. t. iv. p. 380. Some, that there are four; a memory for words, another for places, a third for time, and another for cause and effect. See Gall, l. c. t. ii. p. 353.

[q] *Serm.* i. Upon the social nature of Man. *Serm.* ii. iii. Upon the natural supremacy of conscience.

[r] *Essay on the Constitution of Man, and its Relation to External Objects.* Edinb. 1827.

Upon the subject of metaphysics or the science of mind, all our knowledge, I think, may be found in Dr. Gall's works, — *Sur l'Anatomie et Physiologie du Système Nerveux,* and his *Fonctions du Cerveau;* and the admirable *Lectures on the Philosophy of the Human Mind,* by Thomas Brown, M.D., Edinb. 1826, 4 vols. 8vo.

Dr. Thomas Brown is not only among the ablest metaphysical writers, but is the latest, and his work approaches as near to phrenology as was possible without the aid of Gall's method of investigation.

SECT. VI.

OF HEALTH AND HUMAN NATURE.

74. Since *health*,[a] which is the true subject of physiology, depends upon such an harmony and equilibrium of the matter and powers of the system, as is requisite for the due performance of its physical functions, it is very evident how the four principles, examined above, contribute to its support.

75. *Fluids* properly prepared are the first requisite; in the next place, *solids* duly formed from the fluids; then the invigorating influence of the *vital powers* upon the solids; lastly, a sound *mind* in this sound body.

76. These four principles *act* and *react* perpetually upon each other. The fluids are stimuli to the solids; these again are calculated by their vital powers to experience the influence of these stimuli, and to react upon them. In reference to the intimate union of the mind with the body, suffice it at present to remark, that it is far more extensive than might at first be imagined. For instance, the influence of the will is not confined within the narrow limits of those actions designated voluntary in the schools of physiology; and the mind, on the other hand, is influenced by the affections of the body, in many other ways than by the perceptions of sense, properly so called.[b]

77. From the endless variety and modification of the conditions belonging to these four principles, it may be easily

[a] Theod. G. Aug. Roose, *über die Krankheiten der Gesunden.* Gotting. 1801. 8vo.

G. Chr. Klett, *Tentamen evolvendi notionem de sanitate hominis.* Wirceb. 1794. 8vo.

[b] Galen, *quod animi mores corporis temperaturas sequantur.*

St. J. Van. Geuns, *De corporum habitudine animæ hujusque virium* INDICE *ac* MODERATRICE. Harderv. 1789. 4to.

understood what great *latitude*[c] must be given to the notion of health.

For since, as Celsus long ago observed, almost every one has some part weaker than the rest, Galen may in this sense assert with truth, that no one enjoys perfect health.

And even among those who, in common language, we say are in good health, this is variously modified in each individual.[d]

78. Upon this endless modification is founded the difference of *temperaments*;[e] or, in other words, of the mode and aptitude of the living solid[f] in each individual, to be affected by stimuli, especially the mental; and again, of the mental stimuli, to be excited with greater or less facility.

79. So various are the differences of degree and combination in the temperaments, that their *divisions* and orders may be multiplied almost without end. We shall content ourselves with the four orders commonly received:[g] — The *sanguineous*, — excited most readily, but slightly; The *choleric*, — excited readily and violently; The *melancholic*, — excited slowly, but more permanently; And the *phlegmatic*, — excited the most slowly of all, and indeed with difficulty. (A)

This division, although built by Galen upon an absurd foundation derived from an imaginary depravation of the

[c] Galen, *De sanitate tuenda*, l. i.

[d] W. F. Ad. Gerresheim, *De sanitate cuivis homini propria*. Lugd. Bat. 1764. 4to.

[e] Lavater, *Physiognomische Fragmente*, t. iv. p. 343.

W. Ant. Ficker, *Comm. de temperamentis hominum quatenus ex fabrica et structura corporis pendent*. Gotting. 1791. 4to.

J. N. Hallé, *Mém de la Soc. Médicale d'Emulat.* t. iii. p. 342.

[f] To the numerous arguments by which the moderns have overthrown the doctrine of the ancients, and proved that the temperament depends on the living solids rather than on the nature of the blood, I may add the celebrated example of the Hungarian sister twins, who, at the beginning of the last century, were born united at the lower part of the back, and attained their twenty-second year in this state. They were, as is well known, of very different temperaments, although dissection discovered that their sanguiferous systems anastomosed so considerably that the blood of both must have been the same.

[g] Kant, l. c. p. 257. sq.

elements of the blood, appears, if made to stand alone, both natural and intelligible.

80. The predisposing and occasional *causes* of the diversity of temperaments are very numerous, *v. c.* hereditary tendency, habit of body, climate, diet, religion, mode of life, and luxury.[h]

81. Besides the variety of temperaments, circumstances to which every individual is exposed, increase, by influencing the *number*, as well as the *energy* and *vigour*, of the *functions*, the latitude (77) in which the term health must be received. In regard to age, the health of a new-born infant is different from that of an adult; in regard to sex it differs in a marriageable virgin and an old woman past child-bearing, and during menstruation and suckling; in regard to mode of life, it is different in the barbarous tribes of North America and in effeminate Sybarites. Moreover, in every person, custom (whose great power has obtained for it the title of second nature) has an extraordinary influence[i] over every function, *v. c.* sleep, diet, &c.

82. The more functions flourish simultaneously in the body, the more considerable is its *life*; and *vice versâ*. Hence life is the greatest when the functions have attained their highest exaltation in adult age; and least when the functions, although very perfect according to the course of nature, are fewer and more sluggish, *v. c.* in the newly conceived embryo; life is for the same reason less vigorous during sleep than during the opposite state, &c.

83. The functions have been long divided by physiologists into four classes.[k] This division, although not unexception-

[h] Feder, *Untersuchung über den menschlichen Willen*. T. ii. p. 49.

[i] Galen, *De Consuetudine*.

G. E. Stahl, *De consuetudinis efficacia generali in actibus vitalibus*. Hal. 1700. 4to.

H. Cullen, *De Consuetudine*. Edinb. 1780. 8vo.

C. Natorp, *De vi consuetudinis*. Gött. 1808. 4to.

[k] The very acute Gilbert Blane's classification of the functions of the animal economy according to the powers which direct them, surpasses all other modern attempts of the kind. *Elements of Medical Logic*. London, 1819. 8vo. (p. 14. sqq. of the vernacular version.)

able, nor exactly conformable to nature,[l] may assist the memory.[m]

1. The first class comprehends the *vital* functions, so termed, because their uninterrupted and complete performance is necessary to life; such are the circulation of the blood and respiration.

2. The second comprehends the *animal* functions, by which animals are chiefly distinguished from vegetables; such is the communication of the mind with the body, especially sense, and muscular motion.

3. The third is the *natural*; by means of which the body is nourished.

4. The fourth, the *genital*, intended for the propagation of the species.

We shall now examine each of these separately; beginning with the vital. (B)

NOTES.

(A) The sanguineous temperament is denoted by a full habit, and rather soft fibre, a delicate skin, with large veins, a fresh complexion; often red or yellow, and, occasionally, darkish hair; great sensibility, a quick pulse, free secretions, and a cheerful disposition.

The melancholic, on the contrary, often by a spare habit, by a firm fibre, a thick, dark, hairy skin, black hair and eyes, and a dark complexion: a slow pulse, little sensibility, sparing secretions, and a gloomy cast of character; great perseverance in all pursuits, and constancy of passion.

The choleric lies between the two, and is marked by a softer fibre, a more irritable habit, a less dark and hairy skin, a more

[l] See Platner, *Quæst. Physiol.* p. 31. Ith, *Versuch einer Anthropologie.* t. i. p. 108. 222.

[m] J. J. Bernhard, *Versuch einer Vertheidigung der alten Eintheilung der Functionen, und einer Classification des organisirten Körper nach denselben.* Erf. 1804. 8vo.

florid countenance, a quicker and stronger pulse, and a more irritable mind than the melancholic.

The phlegmatic is characterised by a lax and weak habit, a pale smooth skin generally destitute of hair, very light hair upon the head, a slow weak pulse, small blood-vessels, languid secretions, and dulness of mind and feeling.[n]

The cheerfulness of the sanguineous temperament, and the gloom and constancy of the melancholic, are subject to great exceptions, as they depend entirely upon the developement of certain parts of the brain.[o]

A new view of temperaments has lately been published by Dr. Thomas, of Paris.[p] He arranges them according to the predominance of the head, chest, or abdomen, — the mental, circulatory, or digestive organs: so that we have, — 1. The cranial or encephalic temperament: 2. The thoracic: 3. The abdominal: with their combinations, 4. The encephalo-thoracic: 5. The encephalo-abdominal: 6. The thoracico-abdominal; and, lastly, 7. The mixed, in which all three are equally blended. Men of genius or enterprise are of the first, Hercules may represent the second, Bacchus the third, and the Apollo Belvidere the last.

According to the *relative bulk* of the three regions, will be the *relative* energy of the mental, muscular, or abdominal functions.

The idea is exceedingly ingenious, and capable of extensive application[q]; but evidently does not interfere with the established view of temperaments. For every individual is, throughout his frame, of the sanguineous, or melancholic, &c., and at the same time has a particular proportion of each of the three regions to each other.

(B) The consideration of a division, as ancient as Aristotle, and by some considered preferable to that which Blumenbach adopts, will perhaps form an useful note to the eighty-third paragraph and the greater part of the fourth section.

In this, the functions are arranged in two classes: — the animal constituting one peculiar to animals; and the vital and natural

[n] See Dr. James Gregory's *Conspectus Med. Theoreticæ*, cap. xxiii.

[o] Upon the independence of the character upon the temperament, see Gall, *Sur les Fonctions du Cerveau*, t. ii. p. 142. sqq.

[p] *Physiologie des Tempéramens ou Constitutions*, par F. Thomas, M.D. Paris, 1826.

[q] See the *Phrenological Journal*, Oct. 1827.

united into another, common to vegetables and animals, under the title of organic or vital. The generative, relating in their object to the species rather than to the individual, and of but temporary duration, are thrown into a separate and inferior division, but in fact, except the animal passion, are part of the organic.

We owe the revival of this classification, and our knowledge of the characteristics of each class of functions, to Dr. Wilson Philip, [r] and Xavier Bichat, [s] although the latter, from having published a work expressly on the subject, has received the whole honour, both in Great Britain and on the Continent.

The *animal* functions prove us feeling, thinking, and willing beings: they are the actions of the senses which receive impressions; of the brain which perceives them, reflects upon them, and wills; of the voluntary muscles which execute the will in regard to motion; and of the nerves which are the agents of transmission: The brain is their central organ. The *vital* or *organic* functions are independent of mind, and give us simply the notion of life: they are digestion, circulation, respiration, exhalation, absorption, secretion, nutrition, calorification: The heart is their central organ.

The organs of the animal functions are double and correspondent, there being on each side of the median line of the body, either two distinct organs, as the eyes, ears, extremities; or two correspondent halves, as is the case with the brain, spinal marrow, nose, tongue, &c.

The organs of the vital or organic functions, are, in very few instances, double, or situated with their centres in the median line, and possessed of symmetrical halves; *v. c.* the heart, stomach, liver. There are, indeed, two kidneys, but they continually differ in size, figure, and situation: the two lungs are very dissimilar.

Hence Bichat infers, that in the animal functions a harmony of action in each organ, or in each half of the organ, is indispensable to perfection, when both organs or sides act together; and that if such harmony do not occur, it is better for one organ or one

[r] *Treatise on Febrile Diseases*, ch. iii. sect. 3. First edition. 1799. *Paper read to the Royal Med. Society of Edinburgh*, 1791 *or* 1792, *and inserted in its Records. Essay on Opium.* 1795. *Edinburgh Med. and Surgical Journal,* July, 1809. p. 301. sq.

[s] *Recherches Physiologiques sur la Vie et la Mort.* 1805.

half to act alone. This certainly appears true of the eye, and ear, and even of the brain. It certainly does not hold good in the actions of the voluntary muscles, nor in the operations of the brain or spinal marrow in willing those actions. From the duplicity of the organs it also happens that one side may cease to act without detriment to the function of the other; while, in the vital or organic class, no harmony of action is possible, and the derangement of any one part of an organ generally affects the whole of it, — an obstruction in the colon disturbs the functions of all the alimentary canal.

The animal functions experience periodical intermissions — sleep. The organic or vital continue incessantly, suffering merely remissions: — the blood constantly circulates, the perspiratory fluid is constantly secreted, the stomach has no sooner digested one meal than we commit another to it; yet we shall hereafter see that the actions of the heart, lungs, &c., have intervals of remission.

The animal functions are much influenced by habit; the vital or organic are considered by Bichat as removed from its influence. The power of habit over our sensations and voluntary motions is manifest: yet I think it equally great over the organic functions. The operation of food and of all descriptions of ingesta is most remarkably modified by habit; through it poisons become comparatively innoxious, and divers bear a long suspension of respiration.

Bichat regards the passions as directly influencing the organic functions only, and springing from the state of the organs of that class. Here he is to me perfectly unintelligible. Vexation indeed disturbs the stomach, and fear augments the quantity of urine; but does not vexation equally and as directly disturb the mind, — confuse the understanding, and occasion heat and pain of the forehead? Are not, in fact, the passions a part of the mind? — a part of the animal functions? They powerfully affect, it is true, the organic or vital functions, but this shows the close connection merely between the two classes of functions. [t]

[t] Bordeu, also Buffon, Cabanis, the anatomist Reil, placed the passions in the thoracic and abdominal viscera, &c.; the two first in the diaphragm particularly. Gall has shown the absurdity of these authors in his *Fonct. du Cerveau*, t. ii. p. 93. sqq. We might as well consider the cheeks the seat of the feeling of shame, because in shame we blush.

This connection is conspicuous in respiration, the mechanical part of which belongs to the animal functions, the other to the organic; and in the alimentary functions, in which the food is swallowed and the fæces rejected by volition, and digestion, &c. performed, independently of our influence, by the powers of simple life. So close indeed is this connection, that every organ of the animal class is the seat of organic functions; — in the voluntary muscles, the organs of sense, and even in the brain, circulation, secretion, and absorption are constantly carried on. This connection is likewise apparent in the property of sensibility. In the language of Bichat there are *animal sensibility and contractility*, and *organic sensibility and contractility*, besides the common extensibility of matter, which he terms *extensibilité de tissu*, and common contractility upon the removal of distension, — *contractilité par défaut d'extension*, confounded by Blumenbach (58. clause 5 and 6) with purely vital contractility, and, indeed, greater during life than afterwards.[u] *Animal sensibility* is accom-

[u] The following is Bichat's table of the properties of the living body: —

	Classes.	*Genera.*	*Species.*	*Varieties.*	
Properties.	1 Vital	1 Sensibility	1 Animal		
			2 Organic		
		2 Contractility	1 Animal		
			2 Organic	1 Sensible	Such as the motion of the *heart* and *alimentary canal.*
				2 Insensible	Such as the motion of the *capillaries.*
	2 Structural	1 Extensibility			
		2 Contractility			

Although these are the general properties of the living frame, and sensibility, or more properly excitability, is at the bottom of all the other vital or organic properties except the active power of contraction, yet each part has also some peculiarity, altogether inexplicable, not in the least, I think, to be accounted for on Bichat's supposition of each part possessing a certain *degree* of organic sensibility in relation to its fluids. What causes the vessels of muscle to produce muscle; of bone, bone; of membrane, membrane; what causes the secreting vessels of the liver to form bile, and of the testes semen, we know not. The cause of these circumstances may be called by Blumenbach, after Bordeu, *vitæ propriæ*; but it must be carefully remembered, that this expression simply denotes an unknown cause of a fact, and affords no explanation.

Feeling (I use the word for want of another to embrace consciousness and perception) is in the same manner at the bottom of all the mental properties panied by a perception in the mind, as in seeing, hearing, tasting, smelling, feeling: *animal contractility* is excited by the volition of the mind conveyed to the voluntary muscles by means of the

---

except the active power of willing, but it alone will not explain them. All matter is probably the same; but its *modifications* also are so various, that at present we are compelled to speak of distinct kinds of matter.

The operation of agents on the system is analogous. As far as they all affect the living solid, they may be all called stimuli; but they differ in something more than *degree* of stimulus. Each affects particular parts more than others; each affects in a peculiar way; some directly depress life, and many occasion opposite results in different parts.

When organic sensibility is heightened in one part, it sinks in another, and *vice versa*; unless the change of it should be such as to extend generally, and even then it is still frequently found in the opposite state in some particular part: *v. c.* we notice coldness and paleness of the feet, and heat and fulness of the head, together; blisters relieve internal inflammation, and irritate the more difficultly in proportion to the violence of the internal disease. The same phenomena are observable in animal sensibility and in the mind at large: —

"Tut, man! one fire puts out another's burning,
One pain is lessen'd by another's anguish;
Turn giddy, and be holp by backward turning;
One desperate grief cures with another's languish;
Take thou some new infection to thy eye,
And the rank poison of the old will die."

SHAKSPEARE. *Romeo and Juliet*, act i. sc. ii.

The effect of vicissitudes of temperature, and a large number of other pathological phenomena, are principally explicable on the derangement of the balance of excitability, and for the most part, *consequently*, of circulation. (Sect. XX. (B.))

Notwithstanding it is a general law (53) that the effects of a stimulus diminish the more frequently it is applied, and *vice versa*, as shown on the one hand, in the large quantities of spirituous liquors which persons at length bear, and on the other by the violent inflammation excited by the application of warmth to parts exposed to intense cold; yet, if a stimulus is applied so energetically as to leave the sensibility heightened, especially if to the point of inflammation, its subsequent power is greatly increased. Immense potations of spirituous liquors may gradually be borne, but if the increase is too great, the sensibility of the stomach may become such that a single glass will prove violently irritating.

The general law, to which the effects of stimuli, in proportion to their previous application, is referable, appears to be this; — that a stimulus acts according to the *difference* between its strength and the strength of the former application. Thus, if the right hand be immersed in water of 30°, and the left in water of 50°, and both are removed to water of 70°, the effect of the water at 70° upon the right hand will be greater than upon the left, on account of the difference between 30° and 70° being greater than between 50° and 70°; and this explains the glow of the cold bath, as, during immersion, there is less stimulus, and, on emergnerves. *Organic sensibility* is attended by no perception, and is followed by contraction totally independent of the will : — the

---

ing, the temperature of the atmosphere, and the readmitted blood into the superficial vessels, though stimuli absolutely of the same strength as before immersion, are, *comparatively*, more powerful than what the system experienced during immersion.

The specific action of one agent frequently prevents or destroys that of another : *v.c.* small-pox and measles very rarely occur together ; the former disease is generally prevented for ever by the cow-pock ; bark cures the effect of miasmata. It in some cases destroys its own power in future, as is exemplified in those diseases which occur usually but once during life.

The effects of rare or frequent stimulation may relate to stimulation in general or by particular agents. A very high or low excitement may influence the effects of all subsequent stimuli ; but the rare or frequent application of a particular stimulus in less intensity may influence its own effects only, as exemplified in acquired capability of smoking or taking snuff, while other vapours or powders affect no less than usual.

While moderate excitement is necessary to maintain action and excitability, and excitement by one stimulus, within due limits, augments the effects of another, (54) violent excitement wears out the power, and very violent may suddenly destroy life altogether : according to the verses,

Nutritur ventis, ventis extinguitur ignis,
Lenis alit flammas, grandior aura necat.

Dr. John Brown, seizing the undeniable general facts respecting the effect of rare or frequent application upon the power of stimuli, and naming all agents stimuli, founded a system of pathology and practice at once absurd and destructive. (*Elementa Medicinæ*). Exhaustion, from excess of stimulus, he termed direct debility ; torpor, from deficiency of stimulus, indirect debility ; and however inflammatory a disease, if it arose from a stimulus, it was to be treated by violent stimuli, to prevent the excitability from falling too low.

In the first place, he abused the word stimulus, by confounding it with the word agent, forgetting what has been just advanced respecting the peculiar properties of every agent, — that some depress, and thus, though agents, are not stimuli ; and some affect different parts differently ; and some have a specific power upon certain parts and certain diseases, and against other agents.

In the second place, he forgot what has been just said respecting the necessity of a certain degree of excitement to maintain excitability ; the effect of one stimulus, within due limits, of increasing the effect of others ; and the fact of a stimulus producing so much excitement, that morbid sensibility occurs, far less stimulus than was at first applied causing ten times the effect, and this being reducible only by lessening all stimuli,—the temperature, the quantity of blood, &c., and stimulating distant parts. He forgot, also, the effect of sympathy and specific action.

His error was in keeping in view some general laws, which all know and acknowledge, to the exclusion of others of at least equal importance.

heart is said to feel — (physiology has no proper term for the idea, but *excitability* would answer the purpose) — the stimulus of the blood, and, without our influence, forthwith contracts; the lacteals to feel the stimulus of the chyle without our knowledge, and they then propel it without our assistance.[x] But although we never acquire the least direct voluntary power over the actions of organic contractility, — over the peristaltic motion of the intestines or the contractions of the heart, yet every organ of the organic functions may have its organic sensibility heightened into animal sensibility, as inflammation, for instance, of the pleura and the joints, daily demonstrates; indeed, in some organs of that class of functions, we invariably have sensation; — the stomach is the seat of hunger, in the lungs we experience an uneasy sensation nearly as soon as their air is expelled.

The nerves of the animal functions run to the brain or spinal marrow; those of the organic chiefly to ganglia; but, as might be expected, the two nervous systems have abundant communications.

The animal functions have not only a shorter existence than the organic, from their necessity of alternate repose,[y] but they flourish for a shorter duration, — they do not commence till birth, they decline, and in the natural course of events, terminate, earlier, *v. c.* the organs of sense and the mental faculties fail before the action of the heart and capillaries. But the decay of the animal functions must, in truth, be only the consequence of the decay of the organic, because there are fundamentally in every part organic functions, — circulation, nutrition, &c.; and the perfect performance of these in the organs of the animal functions is indispensable to the perfect performance of the animal functions.

[x] There is no proof of feeling. There can be no feeling. We see them act in consequence of the stimulus, and say they feel. The expression is only admissible figuratively, but as all figurative terms in physiology are continually accepted literally, and establish the most absurd notions, especially among the vulgar, it had much better be explained by a mere expression of the fact, by the word *excitement*.

[y] It is said that the heart has the same repose as the brain, the auricles and ventricles acting in succession, and a pause occurring before their action is renewed. But while these parts are not acting, their functions continue, because they are becoming distended by the blood. The function, therefore, of the heart constantly goes on, while that of the brain entirely intermits in sound sleep.

Hence the impairment of these organic functions, even to a small extent, must derange or diminish the animal functions, and the decline of the latter is really owing to the decline of the former, although these still remain vigorous enough to appear unimpaired.

We thus find in every living system a class of functions, not in themselves dependent upon mind, as perfect in the vegetable as in the animal, and pervading every part of the system. In animals there further exist certain parts which, when endowed with the common life of other parts,—with the organic properties,—are able to perform peculiar functions which give us the notion of mind: the organ of these functions is termed brain, and, by means of nerves and medullary prolongations, it maintains a correspondence with the whole machine, influenced by and influencing the most distant parts. The phenomena of the mind have been metaphysically considered in the fifth section; they will be examined as functions of the nervous system in the twelfth.

The ORGANIC FUNCTIONS depend on LIFE, in the proper acceptation of the word. The word life should be regarded, like the word attraction or repulsion, as merely an expression of a fact. In this point of view it may be as easily defined as any other expression. By LIFE we generally mean the power of organised matter to preserve its particles in such chemical relations as to prevent other chemical relations from inducing disorganisation, or even to increase or decrease by internal appropriation and separation; to produce peculiar matters for its own purposes; to preserve, in some measure, a temperature distinct from that of the surrounding medium; to move certain parts of itself sensibly (as muscles) or insensibly (as the capillaries) independently of mere impulse, attraction, or repulsion: or if not organised (as the fluid which becomes the embryo, the blood,) the power of matter produced by an organised body endowed with the properties above mentioned, to resist the ordinary chemical influences, and even directly form (as the embryotic fluid) an organised system so endowed, or directly become (as the fibrin, when it is secreted from the blood or blood is effused, becoming vascular, and its new vessels inosculating with those of adjoining parts), the organised substance of an already formed system so endowed.

That fluids as well as solids are susceptible of life, I cannot doubt. There is no reason why they should not be so, although a person who has not thought upon the subject may be as unable to conceive the circumstance as a West Indian to conceive that water may by cold become solid. It is impossible to deny that the male or female, or both, or united, genital fluids are alive, because from their union, or one influenced by the other, a living being is produced which partakes of the vital qualities of each parent. Accordingly Blumenbach, in his *Commentatio de vi vitali sanguini deneganda*, grants both male and female genital fluids to be alive [z], notwithstanding that he fancies his victory over the defenders of the blood's life so complete, that like that of the unfortunate Carthaginian Dido, as he says, "*in ventos vita recessit.*" It is as easy to conceive the blood to be alive as the genital fluids. [a]

Many facts adduced as arguments of its life are certainly explicable without such a supposition. Its freedom from putrefaction while circulating may be owing to the constant renovation of its particles, for the thinness of hybernating animals at the end of their torpid

[z] "In universum sane post omnia quæ super hoc argumento sive meditando sive experiundo hactenus elicere licuit, nulli humorum nostri corporis genuina vis vitalis tribuenda videtur, si unice a genitali utriusque sexus latice discesseris, utpote cui jam ante quam uterino cavo exceptus et intime mixtus in fœtus formationem abit, vitales inhærere vires formativas, præter alia paterni vultus in nepotes propagata similitudo, aliaque id genus phænomena haud infitianda demonstrare videntur." *Comment. Soc. Reg. Societ. Gotting.* vol. ix. p. 12.

[a] The doctrine of the life of the blood was maintained by Critias and his sect among the ancients (Aristotle, *De anima*, cap. 2.), Harvey (Exercit. L. *De Generationis ordine*, &c.), Glisson (*De ventriculo et intestinis*), and Albinus. (Blumenbach's *Commentat.* l. c.) I am surprised that Moses should have been adduced by Harvey as authority for this opinion. When he says (*Leviticus*, ch. xvii. 11. 14.), "For the life of the flesh is in the blood" — "For it is the life of all flesh,"—he can only mean, that, when it is withdrawn, life ceases, — that it is necessary to the life of animals. He also says (v. 14.) "the blood of it is FOR the life thereof." The construction which would make Moses assert that the blood is alive, involves the absurd assertion that the blood only is alive. Indeed, before the time of Moses, the expression was used to Noah. In *Genesis* (ix. 4.) we read, "Flesh with the life thereof, which is the blood thereof, shall you not eat." The whole of the matter appears to be, that the Jews, like other neighbouring nations, were in the habit of tearing limbs and cutting flesh from living animals, and eating these portions raw. Saul's army after a battle did this. (*Samuel*, xiv. 32. 33.) To prevent this horrid cruelty, they were forbidden to eat flesh before the animal had been drained of its blood, and thus deprived of life; and what is, in our own version of the Bible, rendered, "flesh with the life thereof, which is the blood thereof," is said to be rendered by the best interpreters, "flesh or members torn from living animals having the blood in them." See Bruce, *Travels to discover the Source of the Nile*, vol. iii. p. 297.

season, shows it has received accessions even in them and from the absorption of fat. Its inability to coagulate after death from arsenic, opium, and some other narcotics, and from lightning and electricity (though Dr. Scudamore found it to coagulate as usual in the latter case), from hard running, anger, or a blow on the stomach, all three of which deprive the muscles of their usual stiffness, may depend upon chemical changes. The admixture of opium with the blood has been said to prevent its coagulation, and this by destroying its life. But Dr. Scudamore found that the admixture of prussic acid and belladonna, both strong poisons, has no such effect, and that many mere salts, as common salts, weaken or prevent its coagulation, and these are not likely to kill it, but to act chemically. Its accelerated coagulation by means of heat, when frozen by cold, and some other circumstances, and the reverse, were believed to depend upon an affection of its vitality, but are, perhaps, referable to the escape or detention of its carbonic acid gas. Its earlier putridity when drawn from young than from old persons may arise from its inferior qualities. Parts die if deprived of a supply of blood, yet, though necessary as a material and agent to maintain the life of parts, it is not, therefore, necessarily itself alive. But the circumstance of it freezing more readily, like eggs, frogs, snails, &c., when once previously frozen, (which change may be supposed to have exhausted its powers,[b]) is, if really the case, an argument in favour of its life, as these are certainly endowed with life. The organisation of extravasated blood,[c] and the inosculation of new vessels with those of surrounding parts, shows[d] that the solidified lymph is now endowed with life; and one may more easily believe it to have been alive in the mass of blood, than that it should have acquired vitality after its effusion. Indeed Sir Everard Home declares that a coagulum of blood becomes vascular out of the body and may be injected;[e] but if the vessels are formed by the

[b] Corrie, *on the Vitality of the Blood*, p. 45.

[c] J. Hunter, *Treatise on the Blood, &c.* p. 1. ch. 1.

[d] Dr. Thomson believes, that when blood has been effused between divided surfaces, its coagulum is absorbed, and *secreted* lymph only coagulates and becomes vascular. *Lectures on Inflammation*, p. 214. Yet at page 216 he does not deny the occurrence.

[e] *Phil. Trans.* vol. cviii. p. 188. sq.

mere extrication of carbonic acid gas, as he contends, their mere formation is no proof of life.

John Hunter believes that the chyle is alive, and some that vivification commences even in the stomach, and Albinus grants life even to the excrement. But the excretions must be regarded as dead matter, useless and foreign to the system, and they all run with the greatest rapidity into decomposition. In operating for retention of urine, the surgeon finds this fluid abominably fœtid; the fæces become so when not discharged in due time; and the neglect of washing the surface is the source of filth and disease.

The essential nature of life is an impenetrable mystery, and no more a subject for philosophical inquiry than the essential nature of attraction or of heat. To attempt explaining the phenomena of life by a vital fluid is only increasing the intricacy of the subject by an unfounded *hypothesis*, and always reminds me of Mr. Dugald Stewart's remark,—" That there is even some reason for doubting, from the crude speculations on medical and chemical subjects which are daily offered to the public, whether it (the proper mode of studying nature) be yet understood so completely as is commonly imagined, and whether a fuller illustration of the rules of philosophising, than Bacon or his followers have given, might not be useful even to physical inquirers."[f] We see matter in a certain state possessed of a certain power which we term life, and the object of physiology is merely to observe its effects, just as it is the object of chemistry to observe the circumstances of the affinity of different bodies and of physics to observe other phenomena of matter, without vainly speculating on the essence of affinity or the essence of matter, to comprehend which our faculties are, in their nature, incompetent. By attributing life, the power of attraction, &c. to subtle and mobile fluids, we not only do not advance a single step, for we have still to explain what these fluids are, and how *they* obtain *their* powers, just as we had before in regard to common matter; but we make the additional mysteries of their being united with ordinary matter, and so united that life appears a power possessed by *it*. The editors of a medical review have in vain searched John Hunter's works

[f] *Elements of the Philosophy of the Human Mind*, vol. i. p. 8.

for such an *hypothesis*,[f] and Mr. Lawrence has had no better success,[g] so that I apprehend his meaning has been misunderstood by those who constitute him its patron.[h] Granting for a moment that *life* depends upon a peculiar, fine fluid, we have still to account for *mind*, because life is not mind,—a cabbage is as much gifted with life as the wisest man. Yet those whose faith makes life a subtle fluid strangely imagine that the doctrine of a soul is thereby advanced. The life of a brute requires a subtle fluid as much as the life of a man, and of a cabbage as much as the life of a brute.

We have reason to believe that life never originates, but began at the creation, and is communicated to assimilated matter and propagated from parent to offspring (XLII. D). It is the property of organised systems, producing various effects by various kinds of organisation, but is not quite peculiar to organised matter, because capable of being possessed by matter in a fluid state.[i]

The ANIMAL FUNCTIONS demonstrate MIND. This is seated in the brain, to which the spinal marrow, nerves, and voluntary muscles are subservient. MIND is the functional power of the

[f] *Annals of Medicine and Surgery*, 1817, p. 373. In the *Treatise on the Blood* (p. 89. sq.), John Hunter says, "Life is a *property* (not a subtle fluid) we do not understand." This property he conceives to reside in a certain matter similar to the materials of the brain; diffused through the body and even contained in the blood. "The brain," he adds, "is a mass of this matter, not diffused through any thing, for the purpose of that thing, but constituting *an organ* in itself." This *materia vitæ* is, therefore, not *subtle*, but pretty solid, and no other than medullary matter; and Vauquelin says he has lately discovered a fatty matter in the blood, and which M. Chevreuil thinks he proves to be the same as the substance of the brain and nerves. But the subtle-fluidists would not tolerate *gross fatty* matter, and J. Hunter calls life a *property*.

[g] *Lectures on the Physiology, Zoology, and Natural History of Man*, p. 84.

[h] J. Abernethy, *Lectures delivered before the Royal College of Surgeons*. 1814.

[i] As the fluids which form the embryo must be endowed with life, organisation cannot be the cause of life; but in truth, organisation is the effect of life, although when produced it becomes an instrument of life. The erroneousness of the French doctrine,—that "life is the result of organisation," was refuted in the *Annals of Medicine and Surgery*. (1816, Sept. p. 346. 386.) The error appears to have arisen in some measure from the want of definition,—the word life being used sometimes properly for the power, sometimes improperly for the result. Even if the result of life,—the functions of a part, should be called its life, life could not be said to be the result of organisation, but of a power to which organisation is an instrument. The Greeks had distinct appellations for the cause and the result; the former they termed ψυχὴ; the latter ζωὴ.

living brain. As I cannot conceive *life* any more than the power of attraction unless possessed by matter, so I cannot conceive *mind* unless possessed by a brain, or by some nervous organ, whatever name we may choose to give it, endowed with life. (XLIV. F). I speak of terrestrial or animal mind; with angelic and divine nature we have nothing to do, and of them we know, in the same respects, nothing. To call the human mind positively a ray of the divinity, (*Divinæ particula auræ,*[k] *Ex ipso Deo decerptus, Ex universa mente delibatus*[l]) appears to me absolute nonsense. Brutes are as really endowed with mind, — with a consciousness of personality, with feelings, desire, and will, as man.[m] Every child is conscious that it thinks with its head, and common language designates this part as the seat of mind.[n] Observation shows that superiority of mind in the animal creation is exactly commensurate with superiority of brain (XLIV. F);[o] that activity

[k] Horace.

[l] Cicero, *De Senectute & Quæst. Tuscul.*

[m] See Gall, l. c. t. 1. p. 56. sqq. Aristotle no sooner asserts that a share of divinity is bestowed on man "only of all animals," than he is obliged to retract, and say "or most of all animals," — ἢ μάλιστα πάντων. *De part. animal.* l.ii. c. 10.

[n] A stupid person is honoured with the expressions numb-*scull,* thick-*head,* addle-*pated,* shallow-*pated,* badly furnished in the *upper story;* a clever person with strong-*headed,* long-*headed,* having plenty of *brains;* a madman is said to be wrong in the *head,* touched in the *noddle,* &c. A person whose memory or power of attention is impaired, says he has no *head,* &c. When a catarrh chiefly affects the head, we complain of stupidity, because "we have such a cold *in the head,*" &c.

[o] "The same progression which exists in the gradual perfection of animal organisation, as far as regards vegetable life only, is observed in the gradual perfection of the nervous system, and of animal life which depends upon it. Comparative anatomy has followed the gradual perfection of animals, from the most simple absorbent vessels to the most complicated apparatus of mastication, deglutition, and digestion, — to the most perfect circulation. With every fresh viscus, every fresh apparatus for sensation, is discovered a fresh function, and this function is more complicated in proportion as the organisation of the viscus or apparatus of sensation is more perfect. The stomach, kidneys, lungs, heart, eyes, ears, are the more complicated as their functions become so.

"The same gradation may be demonstrated in the structure of the brains of the different species. I have demonstrated in the preceding chapter, that the existence of each moral quality and intellectual faculty, depends solely upon the presence of certain determinate cerebral parts, and not upon the whole mass of brain. It follows, that the number of the faculties is in direct proportion to the integrant parts of the brain. In insects, fish, and amphibia, the nervous mass contained in the cerebral reservoir, is still divided into several distinct masses.

of mind and of brain are coequal; and that as long as the brain is endowed with life and remains uninjured, it, like all other

---

The greater part of these are not integrant parts of the brain, properly so called; they are ganglia, from which arise the nerves of smell, hearing, sight, &c. The two hemispheres, properly so called, are placed behind the two ganglia of the olfactory nerves, and are the more complicated as the industrial instincts are more numerous; the cerebellum in these animals generally forms a hollow pouch, sometimes placed horizontally, sometimes folded together.

" In birds, the two hemispheres are already more considerable, although distinct convolutions cannot be discerned. The cerebellum still consists merely of its middle or fundamental part; but already appears composed of many rings placed side by side.

" In the small mammalia, the shrew-mouse, mouse, rat, squirrel, weasel, &c. convolutions are not yet discoverable. But as they are already distinctly found in other larger rodentia, the beaver, kangaroo, &c., we may suppose that they equally exist in them.

" In the larger mammalia, the cat, pole-cat, marten, fox, dog, ape, the convolutions are more distinct and numerous, but their form varies according to the species.

" In the dolphin, elephant, and man, they are more numerous and deep than in the beaver, kangaroo, cat, &c., and their form and direction vary completely according to the species.

" In all the mammalia, the cerebellum possesses, besides the middle or fundamental part, two lateral parts, which are more or less complicated, according to the species; and as the *soi-disant* pons varolii, or the *soi-disant* cerebral ganglia, *i. e.* the transverse layers of nervous bands are only the commmissure or junction of the lateral parts of the cerebellum, they are found in all the mammalia, and in none of the ovipara.

" The number of the integral parts, or of the convolutions of the brain, varies equally in the different species of mammalia; in some, the anterior lobes of the hemispheres are larger or more elevated; in others again, the inferior parts of the anterior lobes are nearly wanting. The middle lobes, and the other convolutions, present similar varieties.

" In this way, the integrant parts of the brain augment in number and development, as we pass from a less perfect to a more perfect animal, till we arrive at the brain of man, who, in the anterior-superior, and in the superior region of the frontal bone, possesses several parts of which other animals are deprived, and by means of which he is endowed with the most eminent qualities and faculties, with reason, and the feeling of religion and the existence of God." Gall, l. c. t. ii. p. 364. sqq. " Some pretend to discover a striking resemblance between the brain of an orang-outang and that of man. But, in the first place, the difference of their volume is as five to one; their convolutions differ considerably in number and structure; the anterior lobes, especially, are contracted into a cone, flattened above, hollow below, &c.; and the difference is still more remarkable in other simiæ." t. vi. p. 298.

organs, can perform its functions, and mind continues; but, as in all other organs, when its life ceases, its power to perform its function ceases, and the mind ceases; when disease or mechanical injury affects it, the mind is affected,—inflammation of the stomach causes vomiting, of the brain delirium, a blow upon the loins causes nephritis or hæmaturia, a blow upon the head stuns; if originally constituted defective, the mind is defective;[p] if fully developed and properly acted on, the mind is vigorous; accordingly as it varies with age, in quality and bulk, is the mind also varied,—the mind of the child is weak and very excitable, of the adult vigorous and firm, and of the old man weak and dull, exactly like

[p] See Gall, l.c. t.i. p. 196. sqq., and t.ii. p. 322. sqq. "Willis has described the brain of a young man imbecile from birth; its volume is scarcely ⅕th part of that of an ordinary human brain. M. Bonn, professor at Amsterdam, has two little crania of idiots, and the brain of an imbecille who attained his twenty-fifth year. He was so stupid, that he was shown for money as an African savage, &c. "I have observed heads equally small in many living idiots from birth. All these crania and heads are 13 or 14 inches in circumference, and 11 or 12 inches from the root of the nose to the foramen occipitale." "With from 14 to 17 inches in circumference; and about 10 or 12 from the root of the nose to the foramen occipitale, we have more or less stupidity, a more or less complete incapacity to fix the attention upon one object; uncertain and transitory feelings and passions; confusion of ideas, &c." "Heads of 18 or 18½ inches in circumference, are still small, although they permit a regular exercise of the faculties; they possess but a sad mediocrity of talent, a spirit of servile imitation, &c.; an extreme deficiency of seizing the relation between cause and effect; a want of self-government, and often few desires. Still some qualities or faculties may be considerable, because particular organs may be greatly developed, forming a striking contrast with the mediocrity of the rest. But as we approach larger brains, we see intellectual faculties of greater magnitude, till we arrive at heads 21 or 22 inches in circumference,—the dimensions at which men obtain the height of intelligence."

"The dimensions of the brain," says Dr. Magendie, "are proportioned to those of the head. In this respect there is a great difference in individuals. The volume of the brain is generally in direct proportion to the capacity of the mind." "It is rarely found that a man distinguished by his mental faculties has not a large head." *Précis de Physiologie*, t. 1. p. 184.

Dr. Marshall, an anatomical lecturer in London from two-and-forty to six-and-twenty years ago, taught that the brain was the organ of mind, its original defective conformation a source of idiocy, its disease the cause of insanity; and gave many dissections of maniacs, and an excellent sketch of the varieties of the disease. *Morbid Anatomy of the Brain, &c. collected from the Papers of the late Andrew Marshall*, M.D., by S. Sawrey, London, 1815.

the body;[q] and the character of the mind of an individual agrees with the character of his body, being equally excitable, languid, or torpid, evidently because the brain is of the same character as

[q] If of children it is said,

—— " Inter se quas pro levibus noxiis iras gerunt?
Quapropter? quia enim qui eos gubernat animus, infirmum gerunt."
Terence, *Hecyra.*

The old man, — " Res omnes timide gelideque ministrat,
Dilator, spe longus, iners—" Horace, *Ars Poetica.*

or, in the plainer language of Shakspeare, " Old men have grey beards, their faces are wrinkled, their eyes purging thick amber and plum-tree gum, and they have a *plentiful lack of wit,* together with most weak hams."

Hamlet, Act 2. Sc. 2.

Mr. Dugald Stewart allows that " In the case of old men, it is generally found that a decline of the faculties keeps pace with the decay of bodily health and vigour. The few exceptions that occur to the universality of this fact, only prove that there are some diseases fatal to life, which do not injure those parts of the body with which the intellectual operations are more immediately connected." *Outlines of Moral Philosophy,* p. 233.

" Præterea gigni pariter cum corpore, et una
Crescere sentimus, pariterque senescere, mentem." Lucretius, lib. i.

" In new-born children, it is difficult to discern, without maceration in spirits of wine, any traces of fibres in the great collections of grey, reddish substances, or the great cerebral ganglia which supply, reinforce, and perfect, or which, according to the opinion of others, give activity to, the hemispheres. The nervous fibres are more visible in the middle and posterior lobes than in the anterior. The fibrous structure of the white substance of the cerebellum also becomes apparent gradually, and in proportion to its development. All the nervous fibres are at this period still so involved in the more or less reddish and gelatinous substance, and in blood-vessels, that all the brain looks like a nervous pulp or jelly.

" The only functions of the infant, at this age, are very imperfect, and are those of the five senses, of voluntary motion, hunger, the sensation of being comfortable or uncomfortable, and the want of sleep.

" After some months, the parts of the brain situated near the anterior-superior region of the forehead, grow more rapidly than the other parts. The forehead, from being flat, becomes prominent, and the child begins to fix its attention upon external objects, to compare, and form abstract ideas, — to generalise.

" The whole brain is developed in succession, until, at the age of from twenty to forty, it has attained its full growth relatively to each individual. The cerebellum, likewise, which is smaller than the cerebrum in proportion as the subject is younger, is developed and perfectly formed towards the age of from eighteen to twenty. The youth, the young man, and the young girl, take an interest in each other; and the talents and inclinations are exercised and perfected till they obtain maturity. From thirty or forty years of age, the cerebrum and cerebellum the rest of the body to which it belongs, — the female mind exceeds the male in excitability as much as her body ;[r] the qualities of the mind are also hereditary,[s] which they could not be, unless they were, like our other qualities, corporeal conditions ; and the mind is often disordered upon the disappearance of a bodily complaint, just as other organs, besides the brain, are affected under similar circumstances, — the retrocession of an eruption may affect the lungs, causing asthma, the bowels, causing enteritis, or the brain, causing insanity, — phthisis and insanity sometimes alternate with each other, just like affections of other organs ; the laws of the mind are precisely those of the functions of all other organs, — a certain degree of excitement strengthens it, too much exhausts it, physical agents affect it, and some specifically, as is the case with other functions, for example, narcotics. The argument of Bishop Butler, that the soul is immortal and independent of matter, because in fatal diseases the mind often

---

remain nearly stationary till the fiftieth or seventieth year, according to individual constitution. The same is the case with the moral and intellectual powers. Certain parts of the brain, however, especially those in the anterior-inferior region of the forehead, have at this time already begun to diminish ; the memory is less faithful, and the imagination less ardent, and hint to us the approach of old age and the decline of our faculties.

"At length all the cerebral mass gradually loses its nervous turgescence ; it diminishes, wastes, shrinks ("the convolutions lie farther from each other;" t. i. p. 192.) ; the consistence of its two substances undergoes alteration. The moral and intellectual powers sink in proportion ; the inclinations, the talents, disappear, the affairs of the world assume a gloomy aspect, the past only is considered good ; and, at the age of decrepitude, there remains only imbecility, the weakness of a second childhood." Gall, l. c. t. ii. p. 156. sqq. Also t. iii. p. 28. sqq. Dr. Magendie allows that "the brain is almost liquid in the fœtus, firmer in infancy, and still more so in manhood :" (*Précis de Physiologie.*) that above the age of seventy, the weight of the brain is on the average $\frac{1}{15}$ less than in the prime of life ; and that the convolutions are then often distant half an inch from each other, and their surface very distant from the cranium, as Cotugno had observed. *Journ. de Physiol.* t. vii. p. 5. 87.

r "Mulieres sunt, ferme ut pueri, levi sententia." — Terence, *Hecyra.*

s "Parentibus liberi similes sunt non vultum modo et corporis formam, sed animi indolem, et virtutes, et vitia. — Claudia gens diu Romæ floruit impigra, ferox, superba : Eadem illachrymabilem Tiberium, tristissimum Tyrannum produxit : tandem in immanem Caligulam et Claudium, et Agrippinam, ipsumque demum Neronem, post sexcentos annos desitura." — Gregory, *Conspectus Medicinæ Theoreticæ.* So true is the verse

Et patrum in natos abeunt, cum semine, mores.

remains vigorous to the last,[t] is perfectly groundless, for any function will remain vigorous to the last if the organ which performs it is not the seat of the disease, nor much connected by sympathy or in other modes with the organ which is the seat of the disease,—the stomach often calls regularly for food and digests it vigorously, while the lungs are almost completely consumed by ulceration. All the cases that are adduced to prove the little dependence of the mind upon the brain, are adduced in opposition to the myriads of others that daily occur in the usual course of nature, and are evidently regarded as extraordinary by those who bring them forward. An exact parallel to each may be found in the affections of every other organ, and each admits of so easy an explanation that it may be always truly said, " Exceptio probat regulam."[u]

[t] *The Analogy of Religion, natural and revealed, to the Constitution and Course of Nature.* By Joseph Butler, LL.D. Lord Bishop of Durham, p. 33.

[u] I will not insult the understanding of my readers by showing that we have no authentic instance of the real absence of brain in the cranium of a being possessed of a mind. The records of medicine no less teem with wonders than those of theology. The miracles of the Fathers and of the Romish Church may be matched by cases not only of mind without brain, or some similar organ, but of human impregnation without males, or by males without testes, and of human fœtuses nourished without communication with the mother.

In most cases where the mind is *said* to have been vigorous when the state of the body at large, or of the brain alone, rendered the perfect performance of the cerebral functions improbable in the eyes of the relaters, I believe the mental power has been greatly overrated,—that, because the individual merely talked collectedly, he was imagined sufficient for the exertions of his best health.

The part of the brain affected by disease may have been one whose function is not intellectual, but merely relating to the feelings, or may have related to intellectual faculties whose state was not noticed by the narrators. In truth, the narrators give us no satisfactory account of the feelings and intellectual powers of the patients, nor of the exact portions of the brain affected; nor could they, being unacquainted with phrenology; and they also forget that the cerebral organs are all double. (See Gall, l. c. t. ii. 188. sqq., 246. sq.; and a paper by Dr. Andrew Combe, on the effects of injuries of the brain upon the manifestation of the mind, in the *Transactions of the Phrenological Society*, Edinb. 1824.)

If after insanity no trace of disease is sometimes discoverable in the brain, let us remember that the same is sometimes the case after epilepsy and various undoubted diseases of the brain, and sometimes with respect to the stomach after chronic dyspepsia. Diseases may be functional only. Nay, when our senses are not nice enough to discover structural affection of the brain in insanity, &c. we have generally strong presumptive evidence of its affection, in the thickening or excessive secretions of its membranes,—points more easily ascertained than equal changes in the delicate texture of the brain.

I have placed the preceding arguments alone, but to them may be subjoined another equally demonstrative as any, — that the strength of the various intellectual powers and inclinations accords with the size of the various parts of the brain; that exactly as the various parts of the brain are successively developed is the character developed, and as they shrink with age does the character again change.

In contending that the mind is a power of the living brain, and the exercise of it the functions of that organ, I contend for merely a physical fact, and no Christian who has just conceptions of the Author of Nature will hesitate to look boldly at Nature as she is, lest he should discover facts opposite to the pronunciations of his revelation ; for the word and the works of the Almighty cannot contradict each other. Lord Bacon accordingly, in a very memorable part of his writings, directs the physical enquirer to be uninfluenced by religious opinions,[x] as the more independently truth is pursued the sooner will it be gained, and the sooner will the real meaning of the divine statement of natural things, and the conformity of this to physical fact, be established.

The assertion, however, that the mind is a power of the living brain, is not an assertion that it is material, for a power or property of matter cannot be matter.

Those who thus attempt to prove the *substantial distinctness* of the mind and brain, forget that their facts, or rather arguments, are equally strong against what they all admit, — the necessary *connection* of the mind and brain in this life, and are therefore grounded on what, if true, were violations of the course of nature.

[x] Si quis animum diligentius advertat, non minus periculi naturali philosophiæ ex istiusmodi fallaci in iniquo fœdere, quam ex apertis inimicitiis, imminere. Tali enim fœdere et societate accepta, in philosophia tantum comprehendi, aucta autem, vel audita, vel in melius mutata, etiam severius et pertinacius excludi. Denique versus incrementa et novas veluti oras et regiones philosophiæ, omnia ex parte religionis, pravarum suspicionum et impotentis fastidii plena esse. Alios siquidem simplicius subvereri, ne forte altior in naturam inquisitio ultra datum et concessum sobrietatis terminum penetret, &c. &c. Quare satis constabat in hujusmodi opinionibus multum infirmitatis, quin et invidiæ et fermenti non parum subesse, &c. — *Cogitata et Visa*, vol. ix. p. 167. 8vo. edition. In the same paragraph he remarks, with regret, that no writers are more popular than those who pompously set forth the union of divinity and philosophy, *i. e.* faith and sense, as if it were not illegitimate. " Haud alias opiniones et disputationes magis secundis ventis ferri reperies, quam eorum, qui, theologiæ et philosophiæ, conjugium veluti legitimum, multa pompa et solemnitate celebrant, et grata rerum varietate animos hominem permulcentes, interim divina et humana inauspicato permiscent."

Neither is it an assertion that this power cannot be a something immortal, subtle, immaterial, diffused through and connected with the brain. A physical enquirer has to do with only what he observes. He finds this power, but attempts not to explain it. He simply says the living brain has this power, medullary matter though it be. Seeing that the brain thinks, and feels, and wills, as clearly as that the liver has the power of producing bile, and does produce it, and a salt the power of assuming a certain form, and does crystallise, he leaves others at liberty to fancy an hypothesis of its power being a subtle, immaterial, immortal substance, exactly as they fancy life to be a subtle fluid, or, perhaps, though very extraordinarily, the same subtle fluid (if subtlety is immateriality and immortality),[y] elucidating the subject no more than in the case of life, and equally increasing the number of its difficulties[z] (p. 64.); as though we were not *created*

---

[y] The hypothesis of a subtle mobile fluid is downright materialism — the doctrine of Lucretius.

—— "Quoniam est animi natura reperta
Mobilis egregie, perquam constare necesse est
Corporibus parvis et levibus atque *rotundis*." Lib. iii. 204.

Bacon complained (l.c.) that those who first attempted to explain thunder and tempests were accused of impiety by religious persons, who thought that religion demanded these phenomena to be referred to the immediate operation of the Deity. The lovers of subtle fluids and spirits, conversely and as strangely, think religion served by interposing a subtle fluid between common matter and the Deity. Van Helmont was remarkably fortunate, for, after severe meditation, he fell into an intellectual vision, and saw his own soul: "Magna mox quies me invasit, et incidi in somnium intellectuale satisque memorabile." It was very small and had no organs of generation: "Vidi enim animam meam satis exiguam, specie humana, sexûs tamen discrimine liberam." *Ortus Medicinæ*, Confessio auctoris, p. 13. He gave the soul, however, a close and dirty dwelling, for he placed it, not in the pineal gland, but in the stomach.

[z] Locke (*Second Reply to the Bishop of Worcester*, p. 477. 8vo. edition) in disparaging *philosophical* reasons for the immortality of the soul, says,

"Dr. Cudworth affirms that there was never any of the ancients before Christianity that held the soul's future permanency after death, (i. e. from its inherent immortality) who did not likewise assert its pre-existence." If we *necessarily* shall exist *to* all eternity, we then must have existed *from* all eternity; yet we are not aware of having been alive before our brains. Sterne's fine ridicule of the absurdities introduced by this hypothesis of a soul, and that independent of the brain, into the Romish church, is well known. A great French man-midwife acquaints us that he baptised a little abortion of the magnitude of a skinned mouse; and on another occasion, when a woman was miscarrying in her fourth beings or not altogether ignorant what matter is, or of what it is capable and incapable; as though matter exhibited nothing but extension, impenetrability, attraction, and inertness; and as though an Almighty could not, if it seemed good to him, have endowed it, as he most evidently has, with the superaddition of life, and even of feeling and will.[a]

Nor does this assertion imply that the resurrection from the dead is impossible or even improbable. The physical enquirer, finding the mind a power of the brain, and abstaining from hypothesis, must conclude that, in the present order of things, when the brain ceases to live the power necessarily ceases,—that,

---

month, and the child's posteriors presented, that he sprinkled water upon them and baptised them, in case the little thing should turn out alive. (De la Motte, *Traité complet des Accouchemens*, p. 243. 246.) Dr. Fodéré in his noted *Médecine Légale*, 1813, (vol. ii. p. 62.) gravely suggests that baptism may always be administered by a squirt, after the membranes are pierced,—"Quant au baptême, il me semble qu'il sera toujours facile de l'administrer, après avoir percé les membranes, par le moyen d'un seringue à injection." A good idea of what follows in its train may be collected from Dante's tiresome account of the introduction of the soul into the body, beginning, "Sangue perfetto che mai non si beve," &c.—*Purgatorio*, canto xxv. It is one parent of necromancy, of the belief in ghosts, and of all the popish "trumpery" respecting purgatory and the worship of dead people called saints, of the opinions held by many respecting our occupations between death and doomsday, as if a future state began before; and old writers sicken one with their notions about the period at which the soul enters the body, when it first existed, how it was engaged before it united with the body, and how it employs itself after its separation till the day of judgment, &c. "Hierom, Austin, and other fathers of the church, hold that the soul is immortal, created of nothing, and so infused into the child or embryo in his mother's womb six months after the conception; some say at three days, some six weeks, others otherwise." Burton's *Anatomy of Melancholy*, p. 1. s. 1. m. 2. subs. 9. Where the depôt of souls is; how they learn when a youth has impregnated an ovarian vesicle, and how they fly to and get into it; how it happens that the qualities of the soul correspond with the brain, and are as hereditary as those of the body; whether this depends upon souls varying, and, if so, how a soul finds a body just corresponding to itself; or upon the soul being obliged to conform to the character of the brain, and thus suffering by the brain's defects (XXXVI. G.): we are not satisfactorily informed.

[a] "All the difficulties that are raised against the thinking of matter, from our ignorance or narrow conceptions, stand not at all in the way of the power of God, if he pleases to ordain it so." The faculties of brutes prove, "either that God can and doth give to some parcels of matter a power of perception and thinking, or that all animals have immaterial and consequently immortal souls as well as men; and to say that fleas and mites, &c. have immortal souls as well as men, will possibly be looked on as going a great way to serve an hypothesis." Locke, *Second Reply to the Bishop of Worcester*, p. 466. 8vo. edit.

in the language of scripture, Dust we are and unto dust we all return,—that our being is utterly extinguished and we go back to the insensibility of the earth whence we were taken.[b] Our consciousness of personality can afford no reason for imagining ourselves immortal and distinct from earth, more than brutes, for this the fly possesses equally with the philosopher about whose head it buzzes.[c] The moral government of the world, the sublime reach of our acuteness, the great improvableness of our characters,—

> " —— this pleasing hope, this fond desire,
> This longing after immortality,
> —— this secret dread and inward horror
> Of falling into nought,"[d]

have been thought to completely harmonise with a life hereafter, but certainly fall so short of proof as to have left the wisest of antiquity, — Solomon, Socrates, Cicero, &c. — in uncertainty,[e] when they saw how death reduces us to our pristine elements. The hope of immortality inspired by such reflections, assisted by the desire of explaining every thing in some way or other, first, I apprehend, made men attempt to find, in the imagined ethereal essence of the soul, a reason for our not totally perishing as our senses would lead us to suppose. But, because we refuse to listen to a mere hypothesis respecting spirit, we are not *necessarily* to deny the resurrection. For if a divine revelation pronounce that there shall be *another order of things* in which the mind shall exist again, we ought firmly to believe it, because neither our experience nor our reason can inform us what will be hereafter, and we must be senseless to start objections on a point beyond the penetration of our faculties.[f] The scripture so pronounces,

[b] *Miscellaneous Tracts, &c.* by Richard Watson, D.D. F.R.S. Lord Bishop of Llandaff. Sermon iii. p. 399. sq.

[c] Heathens have, very consistently with this reason for immortality, given it to the fancied souls of brutes: Ulysses is made by Homer to behold the shade of Orion —

> Θῆρας ὁμȣ εἰλεῦντα, κατ' ἀσφοδελὸν λειμῶνα
> Τοὺς αὐτὸς κατέπεφνεν ἐν οἰοπολοισιν ὄρεσσι. Odyss. Λ. 571.

And "the pious and benevolent Bonnet promised brutes immortality."

[d] Addison, *Cato.* See a full enumeration in Mr. Dugald Stewart's *Outlines*, &c. p. 235. sq.

[e] Bishop Watson, l. c. Sermon vi. p. 504. sq.

[f] "Nor can we be obliged, where we have the clear and evident sentence of reason, to quit it for the contrary opinion, under a pretence that it is a matter of faith, which can have no authority against the plain dictates of reason. But

— not that we are naturally immortal, but that "in Adam (by nature) all die,"[g] — have our being utterly extinguished,[h] and in another order of things, — when the fashion of this world shall have passed away and time shall be no more, that in Christ (by the free, additional, gift of God, granted through the obedience of Christ, but, consequently, *by a miracle*, not by our nature,[i]) — we shall all again be made alive. St. Paul declares the resurrection to be "*a mystery*:" it must, in truth, be a *miracle*, and therefore the enquiry "how can these things be", altogether fruitless. The miracle of Christ's resurrection, to which the scriptures refer us as the foundation of the hope of a future state, would not have been necessary to convince us of a necessary truth, discoverable by sense and reason. That the promises of the New Testament are the proper and *only* foundation of our hopes of immortality, was the opinion of the late Regius Professor of Divinity in the University of Cambridge, whose powerful intellect and sincere love of truth render his opinions weightier than the decrees of councils. "I have no hope of a future existence," says he, "except that which is grounded on the truth of Christianity."[k]

---

there are many things wherein we have very imperfect notions, or none at all; and other things, of whose past, present, or future existence, by the actual use of our faculties, *we can have no knowledge*; these, as being beyond the discovery of our natural faculties, and above reason, are, when revealed, the proper matter of faith. Thus, that part of the angels rebelled against God, and thereby lost their first happy state, and that *the dead shall rise and live again*; these and the like, being beyond the discovery of reason, are purely matters of faith, with which *reason has nothing directly to do*." — Locke, *Essay on Human Understanding*, iv. ch. 18.

Reason's province is only to examine the proofs of the authenticity of a revelation, and faith should thus be founded on reason. But how few of the human race ever think, or are even capable, of carefully examining them! And of those who do examine them, how few do not commence the examination with their minds unconsciously half made up! And yet the greater number look down with a self-complacent and uncharitable feeling upon even good men whose opinions differ in any respect from their own, forgetting that good conduct is the only test of goodness, — that grapes cannot come from thorns, nor figs from thistles.

[g] Bishop Watson, *Apology for the Bible*, Letter x. near the end.

[h] Idem. *Miscellan. Tracts*. l. c.

[i] Idem. *Apology*, l. c.

[k] *Anecdotes of the Life of* Richard Watson, D.D. F.R.S. late Lord Bishop of Llandaff. — Vol. i. p. 107. See also a very decisive passage, beginning

While those are wrong who think there can be any thing like an argument against a future life in another order of things, if declared by a revelation, it is strange that others should think it necessary to attempt rendering the pronunciations of scripture more probable, and that by an hypothesis which is at best but the remains of unenlightened times,[1] and should require any as-

---

" As a Deist I have little expectation; as a Christian I have no doubt, of a future state," in his *Apology for the Bible*, Letter x. near the end.

Locke argues, " that all the great ends of religion and morality are secured barely by the immortality of the soul, without a necessary supposition that it is immaterial." — *First Reply*, p. 34.

Mr. Dugald Stewart concedes that " the proper use of the doctrine of the immateriality of the soul is not to demonstrate that the soul is physically and necessarily immortal." l. c. p. 227.

The celebrated Dr. Rush, of America, remarks upon this subject, " that the writers in favour of the immortality of the soul have done that truth great injury by connecting it necessarily with its immateriality. The immortality of the soul depends upon the will of the Deity, and not upon the supposed properties of spirit. Matter is in its own nature as immortal as spirit. It is resolvable by heat and moisture into a variety of forms; but it requires the same almighty hand to annihilate it, that it did to create it. I know of no arguments to prove the immortality of the soul but such as we derive from the Christian revelation." — *Medical Inquiries and Observations*, vol. ii. p. 15.

" I rather think," says Dr. Priestley, " that the whole of man is of some uniform composition, and that the property of perception, as well as the other powers that are termed mental, is the result (whether necessary or not) of such an organised structure as the brain. Consequently, that the whole man becomes extinct at death, and that we have no hope of surviving the grave, but what is derived from the scheme of revelation." *First Introductory Essay to his Edition of Hartley*, p. xxiii. sq.

[1] The more uninformed the age, the greater the disposition to explain every thing. The savage personifies the winds and the heavenly bodies; the ancients fancied all matter endowed with a spirit — *spiritus intus alit.* Philo and Origen maintain that the stars are so many souls, incorruptible and immortal. In the older writings of the moderns, even in those of the father of experiment and observation — Lord Bacon, the properties of matter are referred to spirits: — " from them and their motions principally proceed arefaction, colliquation, concoction, maturation, putrefaction, vivification, and most of the effects of nature;" " for tangible parts in bodies are stupid things, and the spirits do, in effect, all." (*Natural History*, cent. i. 98.)—In fact, some authors believe in three souls — the vegetable, sensible, and natural — for vegetables, brutes, and man; those who have the second having also the first, and those who have the third having all three. Paracelsus believed in four. These old writers, in providing a spirit for every thing, were more consistent than the moderns, who require it for only life

surance besides that of the gospel, which, they read, "has

---

and mind; because a subtle fluid or spirit is quite as necessary to explain the arrangement of saline particles into the regular form of a beautiful crystal. All these notions still exist among the vulgar; and the last remaining among the better informed, though it too is rapidly dying away, relates to mind. Those who upbraid others for refusing their assent to this hypothesis, may recollect that Anaxagoras and many more were accused of atheism and impiety, because they denied that the heavenly bodies were animated and intelligent. Even in the last reign the Newtonian doctrines were thought irreligious by the Hutchinsonian sect, to which Bishop Horne, the amiable writer on the Psalms, and Mr. Jones, the learned and ingenious writer in defence of the Trinity, belonged: and the Jesuits, in their edition of Newton, 1742, carefully disclaim all belief in his demonstration of the earth's motion, as this is decreed false by the Pope.

Materialist is as good a word as any other for branding those from whom we differ, but materialism in its true acceptation signifies the doctrine of no first cause, or that all has been produced *ex fortuita atomorum collisione*. The whole tenor of scripture implies that *we* are *bodies* endowed with certain properties; and those passages from which our having a distinct immaterial substance is inferred, may be easily explained by the figurative style of the Bible, by the necessary adoption of the language of the times, and by the influence of the national opinions and prejudices of the writers on their modes of expression. Without due allowance, we might deem it impious to deny that "the round world cannot be moved;" that the sun "pursues its course" round the earth; (Galileo was imprisoned for doing so, and yet, said the sage to himself while in prison, "the earth does move" — *e pur si muove*:) that Naaman's leprosy (a condition of body) was a real substance, because we read that it left him and "clave unto Gehazi;" that Adam "surely" died on the very day he tasted the forbidden fruit; that the winds possessed sense, because Christ said "Peace, be still;" that the earth is square, because we twice read of its four corners (*Isa.* xi. *Rev.* vii.); and that Saul's melancholy, and the cases of insanity and epilepsy related in the New Testament, were possessions by demons, which are pronounced by St. Paul to be "nothing in the world." (See the Rev. Hugh Farmer's original and admirable works, especially his *Essays on the Demoniacs of the New Testament*, and *on Christ's Temptation*.) Without due allowance, what absurdities might not be inferred from Christ's use of the word heart? But the most enlightened divines allow us at present to follow Bacon's advice, and to read the Bible, not as a work of philosophical instruction, but of the revelation of religious matters beyond our knowledge, *v.c.* to learn from Genesis only how the world was created by God, and to study geology without reference to Moses. "The expressions of Moses are evidently accommodated to the first and familiar notions derived from the sensible appearances of the earth and heavens, and the absurdity of supposing that the literal interpretation of terms in Scripture ought to interfere with the advancement of philosophical enquiry, would have been as generally forgotten as renounced, if the oppressors of Galileo had not found a place in history." *A Treatise on the Records of the Creation*, &c., by J. B. Sumner, M.A. Prebendary of Durham, &c. 3d edit. 1825, vol. i. p. 327. We may, therefore, learn the miracle of the brought life and immortality to light."[m] They should reflect that the belief of an immaterial substance removes no imagined difficulty, as it is the peculiar doctrine of scripture, in distinction to that of all the heathen philosophers and people,[n] that the resurrection will be positively of *body*, —that in our *flesh* we shall see God,[o] and that therefore our minds must appear as much a property of body hereafter as at present.[p]

---

resurrection from the gospels, and enjoy our own opinions respecting matter and spirit, body and soul, which, as relating to our nature, are objects of physical enquiry, and therefore not of revelation, any more than astronomy or geology. The writer of the celebrated *Apology for the Bible* says, "when I went to the University, I was of opinion, as most schoolboys are, that the soul was a substance distinct from the body, and that when a man died, he, in classical phrase, breathed out his soul, *animam expiravit;* that it then went I knew not whither, as it had come into the body, from I knew not where nor when, and had dwelt in the body during life, but in what part of the body it had dwelt I knew not." "This notion of the soul was, without doubt, the offspring of prejudice and ignorance." "Believing as I do in the truth of the Christian religion, which teaches that men are accountable for their actions, I trouble not myself with dark disquisitions concerning necessity and liberty, matter and spirit; hoping as I do for eternal life through Jesus Christ, I am not disturbed at my inability clearly to convince myself that the soul is or is not a substance distinct from the body." *Anecdotes of the Life of Bishop Watson,* p. 14. sqq.

"Well indeed is it for us," says a liberal writer in the *Quarterly Review,* on the subject of geology, "that the cause of revelation does not depend upon questions such as these; for it is remarkable that in every instance the controversy has ended in a gradual surrender of those very points which were at one time represented as involving the vital interests of religion. Truth, it is certain, cannot be opposed to truth. How inconsiderate a risk then do those advocates run who declare that the whole cause is at issue in a single dispute, and that the substance of our faith hangs upon a thread — upon the literal interpretation of some word or phrase against which fresh arguments are springing up from day to day." 1823, April. p.163.

For an account of all the hypotheses that have been taught upon life and mind, see *An Enquiry into the opinions, ancient and modern, concerning life and organisation.* By John Barclay, M. D. Edinb. 1822.

[m] 2 Timothy, i. 10.

[n] *Errant exsangues sine corpore et ossibus umbræ.* Ovid, *Metam.* iv.

[o] *Job.*

[p] It is the doctrine of the Church of England, that all men *shall rise with their bodies.* Enoch and Elijah are represented to have been translated *bodily.* Nay, our church has so little of this horror of matter, that it declares that Christ, "the very and eternal God" (Article ii.), ascended into heaven, and there sits, with "his body, with *flesh, bones,* and all things appertaining to the perfection of man's nature." Article iv.

This only, the christian, doctrine of a future state is reasonable. The heathen doctrine was grounded on the supposed inherent immortality of a supposed substance distinct from the body. The christian doctrine teaches the resurrection of what we obviously are — bodies, and that through a miracle of the Almighty.[q]

---

[q] Respecting a difficulty which may present itself to the conceptions of some Christians, but which the *miraculousness* of a future existence, I think, should remove, I may quote Paley's sermon on the state after death. He concludes,

"That it is a question by which we need not be at all disturbed, whether the bodies with which we shall arise be new bodies, or the same bodies under a new form;

"For no alteration will hinder us from remaining the same, provided we are sensible and conscious that we are so, any more than the changes which our visible person undergoes even in this life, and which from infancy to manhood are undoubtedly very great, hinder us from being the same, to ourselves and in ourselves, and to all intents and purposes whatsoever." — *Sermons on several Subjects*, by the late Rev. W. Paley, D.D. serm. 3. p. 96. These are a small system of divinity, and, having been bequeathed by him to his parishioners, probably contain his mature convictions.

SECT. VII.

ON THE MOTION OF THE BLOOD.

84. The blood, to whose great and multifarious importance in the system we have slightly alluded (16), is conveyed, with a few exceptions (5), into the most internal and extreme recesses. This is proved by the minute injection of the vessels, and by the well known fact of blood issuing from almost every part on the smallest scratch.

85. This red fluid does not, like an Euripus, ebb and flow in the same vessels, as the ancients imagined, but pursues a circular course; so that being propelled from the heart into the arteries, it is distributed throughout the body, and returns again to the heart through the veins.[a]

86. We shall, therefore, say something at present of the *vessels* which contain the blood; and afterwards, of the *powers* by which they propel and receive it.

87. The vessels which receive the blood from the heart and distribute it throughout the body, are termed *arteries*.

These are, upon the whole, less capacious than the veins: but in adult, and advanced age especially, of a texture far more solid and compact, very elastic and strong.

88. The arteries consist of three *coats*: [b]

[a] Among warm-blooded animals, the egg, especially at the fourth and fifth day of incubation, if placed under a simple microscope, such as the Lyonetian, is most adapted for the demonstration of the circulation.

Among frogs, the most proper is the equuleus of Lieberkühn, described in the *Mém. de l'Acad. de Berlin,* 1745.

[b] For the various opinions respecting the number and differences of the arterial coats, consult among others Vinc. Malacarne, *Della Osservat. in Chirurgia.* Turin. t. ii. p. 103.

And C. Mondini, *Opuscoli scientifici,* t. i. Bologna, 1817. 4to. p. 161.

I. The exterior, called, by Haller, the TUNICA CELLULOSA PROPRIA; by others, the nervous, cartilaginous, tendinous, &c. It is composed of condensed cellular membrane, externally more lax, internally more and more compact: blood vessels are seen creeping upon it:[c] it gives very great tone and elasticity to the arteries.

II. The middle coat consists of transverse fibres,[d] lunated or falciform, and *almost of* a fleshy nature: hence this has the name of muscular coat, and appears to be the chief seat of the vital powers of the arteries.

III. The inner coat lining the cavity of the arteries is highly polished and smooth.

This is much more distinct in the trunks and larger branches than in the smaller vessels.

89. Every artery *originates*, either

From the pulmonary artery (the vena arteriosa of the ancients), which proceeds from the anterior ventricle of the heart and goes to the lungs;

Or from the aorta, which proceeds from the posterior ventricle and is distributed throughout the rest of the system.

These trunks divide into branches, and these again into twigs, &c.

90. According to the commonly received opinion, the united capacity of the *branches* in any part of the sanguiferous system, is greater than that of the trunk from which they arise. But I fear that this is too general an assertion, and even that the measure of the diameter has been sometimes improperly confounded with that of the area. I myself have never been able to verify it, although my experiments have been frequently repeated, and made, not on vessels injected with wax, after the bad example of some illustrious physiologists, but on the undisturbed vessels of recent subjects, *v. c.* on the innominata and its two branches — the right carotid

[c] Fr. Ruysch, *Respons. ad ep. problematicam.* iii. Also his *Thesaur. Anat.* iv. tab. 3.

[d] B. S. Albinus, *Annot. Academ.* l. iv. tab. 5. fig. 1.

and subclavian, on the brachial and its two branches — the radial and ulnar.[e]

The inconstancy of the proportion between the capacity of the branches and that of the trunks is clearly shown by the various sizes of the vessels under different circumstances, *v. c.* by the relative capacity of the inferior thyreoid artery in the infant and the adult; of the epigastric artery in the virgin and the mother near her delivery; and also of the uterine vessels in the virgin and the pregnant woman; of the omental vessels during the repletion and vacuity of the stomach.[f]

91. The arteries, after innumerable divisions and important anastomoses[g] connecting different neighbouring branches, *terminate* at length in the beginning of the veins. By this means, the blood is conveyed back again to the heart. The distinction between artery and vein, at the point of union, is lost.

In the present state of our knowledge, the umbilical vessels are to be regarded as the only exception to the termination of arteries in veins. We shall show that they are connected with the uterine vessels by the intervention of a spongy substance, called parenchyma.

92. Another description of vessels arise universally from the arteries, and are called *colourless*, from not containing pure blood, either on account of their minuteness, or of their specific irritability which causes them to reject that fluid. Such are the *nutrient* and other *secretory* vessels: of which hereafter.

[e] See also J. Theod. Van Der Kemp, *De Vita*. Edinb. 1782. 8vo. p. 51. And Seerp Brouwer, *Quæstiones Medic. varii argum*. Lugd. Batav. 1816. 4to. p. 8.

[f] This is remarkably observable in the adult stag, by comparing the areæ of the external carotid and its branches, during the spring, just before the horns have attained their full growth and when they are still covered with their downy integuments (called in German, *dér Bast*), with such as they are after this covering has fallen off.

[g] Ant. Scarpa, *Sull' Aneurisma*, Pav. 1804. fol. cap. 4.

93. The blood conveyed from the heart throughout the body by the arteries is carried back by the *veins.*[h]

These are very different in function and structure from the arteries, excepting, however, the minutest of both systems, which are indistinguishable.

94. The veins, except the pulmonary, are universally more capacious than the arteries; more ramified; much more irregular in their course and division; in adult age, softer and far less elastic, but still very firm and remarkably expansile.

95. Their *coats* are so much thinner that the blood appears through them. They are likewise less in number, being solely a cellular external, somewhat resembling the nervous of the arteries; and a very polished internal, also nearly agreeing with that of the arteries.

A muscular coat exists only in the trunks nearest the heart.

96. The interior coat forms, in nearly all veins of more than a line in diameter, very beautiful valves, of easy play, resembling bags, generally single, frequently double, and sometimes triple, placed with their fundus towards the origin of the vein and their edge towards the heart.

These valves are not found in some parts; not in the brain, heart, lungs, secundines, nor in the system of the vena portæ.

97. The twigs, or, more properly, the radicles, of the veins, unite into branches, and these again into six principal trunks: viz.

Into the two cavæ, superior and inferior:

And the four trunks of the pulmonary vein (the arteria venosa of the ancients).

The vena portæ is peculiar in this, that, having entered the liver, it ramifies like an artery, and its extreme twigs pass

[h] H. Marx, *diatr. præmio ornata, de structura atque vita venarum.* Carlsr. 1819. 8vo.

into the radicles of the inferior cava, thus coalescing into a trunk.

98. That the blood may be properly distributed and circulated through the arteries and veins, nature has provided the *heart*,[i] in which the main trunks of all the blood vessels unite, and which is the grand agent and mover of the whole human machine, — supporting this — the chief of the vital functions, with a constant and truly wonderful power, from the second or third week after conception to the last moment of existence.

99. The heart alternately receives and propels the blood. Receiving it from the whole body by means of the superior and inferior vena cava, and from its own substance through the common orifice of the coronary veins, that is supplied with a peculiar valve,[k] it conveys that fluid into the anterior sinus and auricle, and thence into the corresponding ventricle, which, as well as the auricle, communicates with both orders of the heart's own vessels by the openings of Thebesius.[l]

100. From this anterior, or, in reference to the heart of some animals, right, ventricle, the blood is impelled through the pulmonary artery into the lungs: returning from which, it enters the four pulmonary veins and proceeds into their common sinus and the left, or, as it is now more properly termed, posterior, auricle.[m]

101. The blood flows next into the corresponding ventricle; and then, passing into the aorta, is distributed through the arterial system of the body in general and the coronary vessels of the heart itself.[n]

[i] W. Cowper, *Myotomia Reformata.* (Posth.) Lond. 1724. fol. max. Tab. xxxvi—xl.

[k] Casp. Fr. Wolff on the origin of the large coronary vein, *Act. Acad. Scient. Petropol.* 1777. P. i.

Petr. Tabarrani on the same subject, *Atti di Siena.* vol. vi.

[l] Respecting these openings consult among others J. Abernethy, *Philos. Trans.* 1798. p. 103.

[m] James Penada, *Memorie della Societa Italiana.* t. xi. p. 555.

[n] Consult Achil. Mieg, *Specimen ii. Observationum Botanicarum,* &c. Basil, 1776. 4to. p. 12. sq.

102. Having proceeded from the extreme twigs of the general arterial system into the radicles of the veins, and from the coronary arteries into the coronary veins, it finally is poured into the two venæ cavæ, and then again pursues the same circular course.

103. The regularity of this circular and successive motion through the cavities of the heart is secured, and any retrograde motion prevented, by *valves*, which are placed at the principal openings, *viz.* at the openings of the auricles into the ventricles, and of the ventricles into the pulmonary artery and aorta.

104. Thus the ring, or venous tendon, which forms the limit of the anterior auricle and ventricle, descending into the latter cavity, becomes these tendinous valves.[o] These were formerly said to have three apices, and were, therefore, called triglochine or *tricuspid:* they adhere to the fleshy pillars, or, in common language, the papillary muscles.

105. In a similar manner, the limits of the posterior auricle and ventricle are defined by a ring of the same kind, forming two valves, which, from their form, have obtained the appellation of *mitral.*[p]

106. At the opening of the pulmonary artery[q] and aorta[r] are found the triple *semilunar* or sigmoid valves,[s] fleshy and elegant, but of less circumference than the mitral.

107. It is obvious how these differently formed valves must prevent the retrocession of the blood into the cavities which it has left. They readily permit the blood to pass on, but are expanded, like a sail, against it, by any attempt at retrograde movement, and thus close the openings.

[o] Eustachius, tab. viii. fig. 6. — tab. xvi. fig. 3. — Santorini. Tab. Posth. ix. fig. 1.

[p] Eustachius, tab. xvi. fig. 6.

[q] Eustachius, tab. xvi. fig. 4.

[r] Eustachius, tab. xvi. fig. 5. — Morgagni, *Adversar. Anat.* i. tab. iv. fig. 3. Santorini, l. c.

[s] Consult Hunter, who treats very minutely of the mechanism of these valves in his work *On the Blood,* p. 159.

108. The *texture* of the heart is peculiar: fleshy, indeed, but very dense and compact, far different from common muscularity.[t]

It is composed of fasciculi of fibres, more or less oblique, here and there singularly branching out, variously and curiously contorted and vorticose in their direction, lying upon each other in strata, closely interwoven between the cavities, and bound by four cartilaginous bands at the basis of the ventricles, which thus are, as it were, supported and are distinguished from the fibres of the auricles.[u]

109. These fleshy fibres are supplied with very soft nerves,[x] and an immense number of blood vessels, which arise from the coronary arteries, and are so infinitely ramified,[y] that Ruysch described the whole structure of the heart as composed of them.[z]

110. This universal vital viscus is loosely contained in the *pericardium*,[a] which is a membraneous sac, arising from the mediastinum, very firm, accommodated to the figure of the heart, and moistened internally by an exhalation from the arteries of that organ. Its importance is evinced by its existence being, in red blooded animals, as general as that of the heart; and by our having but two instances on record of its absence in the human subject.[b]

111. By this structure the heart is adapted for its perpetual

[t] Leop. M. A. Caldani, *Memorie lette nell' Acad. di Padova.* 1814. 4to. p. 67.

[u] Casp. Fr. Wolff, *Act. Acad. Scientiar. Petropol.* for the year 1780. sq., especially for 1781. P. i. p. 211. sq., on the cartilaginous structure of the heart, or on the cartilagineo-osseous bands, and their distribution at the base of the heart.

[x] Scarpa, *Tabulæ Neurologicæ ad illust. Hist. Anat. cardiac. nervor.* tab. iii. iv. v. vi.

[y] Ruysch, *Thesaur. Anat.* iv. tab. iii. fig. 1, 2.

[z] Brandis has proposed an ingenious hypothesis to explain the use of so great an apparatus of coronary vessels. *Versuch über die Lebenskraft.* p. 84.

[a] Haller, *Elementa Physiol.* t. i. tab. i.
Nicholls, *Philos. Trans.* vol. lii. P. i. p. 272.

[b] Consult, *v. c.* Littre, *Hist. de l'Academie des Sc. de Paris.* 1712. p. 37.
Baillie, *Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge*, t. i. p. 91.

and equable motions, which are an alternate systole and diastole, or contraction and relaxation of the auricles and ventricles in succession. (A)

112. Thus, as often as the auricles contract to impel the blood of the venæ cavæ and pulmonary veins into the ventricles, the latter are at the same moment relaxed, to receive the blood: immediately afterwards, when the distended ventricles are contracting to impel the blood into the two great arteries, the auricles relax and receive the fresh venous supply.

113. The systole of the ventricles, upon which is said to be spent $\frac{1}{3}$ of the time of the whole action of the heart, is performed in such a way that their external portions are drawn towards their septum, and the apex of the heart towards the base.[a] This at first sight seems disproved by the circumstance of the apex striking against the left nipple, and, consequently, appearing elongated, — a circumstance, however, to be attributed to the double impetus of the blood flowing into the auricles and expelled from the ventricles, by which double impetus the heart must be driven against that part of the ribs. (B)

114. The impulse imparted by the heart to the blood, is communicated to the arteries, so that every systole of the heart is very clearly manifested in those arteries which can be explored by the fingers and exceed $\frac{1}{6}$ of an inch in the diameter of their canal, and in those also whose pulsation can be otherwise discovered, as in the eye and ear. The effect upon the arteries is called their diastole, and is perfectly correspondent and synchronous with the systole of the heart.

115. The quickness of the heart's pulsations during health varies indefinitely; chiefly from age, but also from other conditions which at all ages form the peculiar constitution of an individual: so that we can lay down no rule on this point. I may, however, be permitted to mention the varieties which

[a] Consult Ant. Portal, *Mémoires sur la Nature & le Traitement de plusieurs Maladies*, t. ii. 1800. p. 281.

I have generally found in our climate[b] at different ages, beginning with the new-born infant, in which, while placidly sleeping, it is about 140 in a minute.

Towards the end of the first year, about	124
. . . . second year	110
. . . . third and fourth year	96
When the first teeth begin to drop out	86
At puberty about	80
At manhood about	75
About sixty	60

In those more advanced, I have scarcely twice found it alike.

116. The pulse is, cæteris paribus, more frequent in women than in men, and in short than in tall persons. A more constant fact, however, is its greater slowness in the inhabitants of cold climates.[c]

Its greater frequency after meals and the discharge of semen, during continued watchfulness, exercise, or mental excitement, is universally known. (C)

117. The heart rather than the arteries is to be regarded as the source of these varieties, which we have, therefore, detailed here.

Its action continues in this manner till death, and then all its parts do not, at once, cease to act; but the right portion, for a short period, survives the left.[d]

For, since the collapsed state of the lungs after the last expiration impedes the course of the blood from the right

[b] My observations differ but little from those made by W. Heberden in England, *Med. Trans.* vol. ii. p. 21. sq.

[c] J. H. Schönheyder, *De Resolutione et Impotentia motus Muscularis.* Hafn. 1768. p. 15. With which work compare the observations of F. Gabr. Sulzer, *Naturgesch. des Hamsters.* p. 169.

[d] Stenonis, *Act. Hafniens.* t. ii. p. 142.

Sometimes, though rarely, it happens that the right portion of the heart, oppressed with too much blood, becomes, contrarily to what usually takes place, paralysed before the left. This I have more than once observed on opening living mammalia, particularly rabbits.

side, and the veins must be turgid with the blood just driven into them from the arteries, it cannot but happen that this blood, driving against the right auricle, must excite it to resistance for some time after the death of the left portion of the heart.

118. This congestion on the right side of the heart affords an explanation of the small quantity of blood found in the large branches of the aorta.

Weiss,[e] and after him Sabatier,[f] ascribe to this cause likewise the comparatively larger size[g] of the right auricle and ventricle after death, especially in the adult subject.

119. The motion of the blood is performed by these two orders of vessels in conjunction with the heart. Its celerity in health cannot be determined. For this varies not only in different persons, but in different parts of the same person.

Generally, the blood moves more slowly in the veins than in the arteries, and in the small vessels than in the large trunks, although these differences have been overrated by physiologists.

The mean velocity of the blood flowing into the aorta is usually estimated at 8 inches for each pulsation, or about 50 feet in a minute.

120. Some have affirmed that the globules of the cruor move more in the axis of the vessels, and with greater rapidity, than the other constituents of the blood. I know not whether this rests upon any satisfactory experiment, or upon an improper application of the laws of hydraulics; improper, because it is absurd to refer the motion of the blood through living canals, to the mere mechanical laws of water moving in an hydraulic machine. I have never been able to observe this peculiarity of the globules.

My persuasion is still more certain that the globules pass

[e] J. N. Weiss, *De Dextro Cordis Ventriculo* POST MORTEM *ampliori.* Altorf. 1767. 4to.

[f] Ant. Chaum. Sabatier, *E, in vivis animalibus Ventriculorum Cordis eadem capacitas.* Paris, 1772. 4to.

[g] Sam. Aurivilius, *De Vasorum Pulmonal. & Cavitat. Cordis inequali amplitudine.* Gotting. 1750. 4to.

on with the other constituents of the blood, and are not rotated around their own axis; — that besides the *progressive*, there is no *intestine* motion in the blood, although indeed there can be no doubt that the elements of this fluid are occasionally divided, — where they are variously impelled according to the different direction, division, and anastomoses of the vessels.

121. The moving *powers* of the sanguiferous system are now to be examined: first, those of the heart, by far the greatest of all; afterwards, those which are only subsidiary, though indeed highly useful.

122. That the powers of the heart cannot be accurately calculated is clear, upon reflecting that neither the volume of the blood projected at each pulsation, nor the celerity nor distance of its projection, much less the obstacles to the powers of the heart, can be accurately determined, &c.

123. A rough calculation may be made by taking every probable conjecture together: *v.c.* if the mean mass of the blood is considered as 10 pounds, or 120 ounces; the pulsations 75 in a minute, or 4500 in an hour; and the quantity of blood expelled from the left ventricle at each contraction, as 2 ounces; it follows that all the blood must pass through the heart 75 times every hour.

The impetus of the blood passing from the heart, may be conceived by the violence and altitude of the stream projected from a large wounded artery situated near it. I have seen the blood driven at first to the distance of above 5 feet from the carotid of an adult and robust man.[h]

[h] The experiments of Hales, in which the blood was received into very long glass tubes fixed to the arteries of living animals, and the length of its projection measured, are indeed beautiful, like every thing done by this philosopher, who was calculated by nature for such enquiries. But, if the force of the heart is to be estimated in this way, we must take into account the pressure of the column of blood contained in the tube and gravitating upon the left ventricle.

The result of Hales's calculations was, that the blood being projected from the human carotid to the height of seven feet and a half, and the surface of the left ventricle being fifteen square inches, a column of blood, weighing 51.5 lbs. was incumbent upon the ventricle and overcome by its systole. *Statical Essays*, vol. ii. p. 40. London, 1733. 8vo.

124. This wonderful, and, while life remains, constant, strength of the heart, is universally allowed to depend upon its *irritability*, (41) in which it very far surpasses, especially as to duration, [i] (98) every other muscular part. [k]

That the parietes of the cavities are excited to contraction by the stimulus of the blood, is proved by the experiment of Haller, who lengthened at pleasure the motion of either side of the heart, by affording it the stimulus of the blood for a longer period than the other. [l] (D)

125. Since a supply of nerves and blood is requisite to the action of the voluntary muscles, it has been enquired whether these, both or either, are requisite to the heart also. [m]

The great influence of the *nerves* over the heart, is demonstrated by the size of the cardiac nerves, and by the great sympathy between the heart and most functions, however different. A convincing proof of this, is the momentary sympathy of the heart during the most perfect health [n] with all the passions, and with the *primæ viæ* in various disorders.

The great importance of the blood to the irritability of the heart, is evident from the great abundance of vessels in its muscular substance.

[i] Thus, to say nothing of the phenomena so frequently observed in the cold-blooded amphibia and fishes, I lately found the heart of the chick to beat for twelve hours, in an egg, on the fourth day of incubation.

[k] Consult Fontana, who treats of this prerogative of the heart minutely in his *Ricerche sopra la Fisica animale*, and limits it too much. Haller answered him in the Literary Index of Gottingen.

[l] See Haller on the motion of the heart from stimulus, *Comment. Soc. Scient. Gottingens.* tom. i.

G. E. Remus, *Experimenta circa circulat. sanguin. instituta.* Gotting. 1752. 4to. p. 14.

[m] On this dispute consult *v. c.* R. Forsten, *Quæstion. select. Physiol.* Lugd. Bat. 1774. 4to.

J. B. J. Behrends, *Dissert. qua demonstratur cor nervis carere.* Mogunt. 1792. 4to.

And, on the other side, J. Munniks, *Observationes variæ.* Groning. 1805. 4to.

Lucæ, l. c. p. 37. tab. ii.

[n] And how much more so when the heart is diseased, is shown *v. c.* in Caleb Hillier Parry's *Inquiry into the Symptoms and Causes of the* SYNCOPE ANGINOSA, *commonly called* ANGINA PECTORIS. Bath, 1799. p. 114.

Nevertheless it is very probable, that the importance of the nerves in this respect is greater in the voluntary muscles, and of the blood in the heart.

126. Besides these powers of the heart, there is another, which is mechanical, dependent on structure, and contributing greatly, in all probability, to sustain the circulation. For, when the blood is expelled from the contracted cavities, a vacuum takes place, into which, according to the common laws of *derivation*, the blood from the venous trunks must rush, being prevented, by means of the valves, from regurgitating. [o] (E)

127. We must now enquire what powers are exerted by other organs in assisting the circulation. The existence of some *secondary* powers and their ability to assist, or even in some cases to compensate for, the action of the heart, are proved by several arguments: *v.c.* the blood moves in some parts to which the influence of the heart cannot reach,—in the vena portæ and placenta; not to mention instances of the absence of the heart. [p]

128. The principal of these powers is the function of the *arteries*, not easy indeed to be clearly understood and demonstrated. 1. It is well known that they have a peculiar coat, which is all but muscular. (88) (F) 2. That they are irritable, has been proved by repeated experiments. [q] 3. The size of the soft nerves arising from the sympathetic, and sur-

[o] Andr. Wilson, *Inquiry into the moving powers employed in the Circulation of the Blood.* Lond. 1784. 8vo. p. 55. sq.

And at great length in J. Carson's *Inquiry into the Causes of the Motion of the Blood.* Ibid. 1815. 8vo.

[p] See *v. c.* C. W. Curtius, *De monstro humano cum infante gemello.* Lugd. Bat. 1762. 4to. p. 39.

W. Cooper, *Philos. Transact.* vol. lxv. p. 316.

And, instar omnium, Fr. Tiedemann, *Anatomie der Kopflosen Missgeburten.* Landshut, 1813. fol. p. 70. sq.

[q] Walter Vershuir, *De arteriar. et venar. vi irritabili: ejusque in vasis excessu; et inde oriunda sanguinis directione abnormi.* Groning. 1766. 4to.

Rich. Dennison, *Diss. arterias omnes et venarum partem irritabilitate præditas esse.* Edinb. 1775. 8vo.

Chr. Kramp, *De vi vitali arteriarum.* Argent. 1785. 8vo.

rounding the larger arterial branches with remarkable networks, particularly in the lower part of the abdomen,[r] argues the importance of these vessels in assisting the motion of the blood.[s]

129. All know that the arteries pulsate, and indeed violently, so that if, *v. c.* we place one leg over the other knee, we find not only that it, but even a much greater weight, may be raised by the pulsation of the popliteal. Hence an alternate systole and diastole, corresponding with those of the heart, have long been assigned to them.

But this, although commonly believed on the evidence of sense, is open to much question:[t] it may be asked, especially, whether this pulsation is referable to the power of the artery, or only to the impulse given by the heart to the blood propelled into the aorta.

130. And indeed, after all, it appears that the *diastole* of an artery is owing to a lateral distension given by the impetus of the blood, so that the coats are expanded, and, by their elasticity, the next moment reacquire their natural thickness. To the same impulse may be ascribed the lateral motion of the axis, observable in the larger arteries, if serpentine and lying in loose cellular substance. (G)

The genuine *systole*, produced by a contraction of their substance, scarcely occurs, probably, while the heart acts with vigour, but may, when they are unusually influenced by local stimulants; whence the pulse during illness is very different in different arteries of the same person at the same time; or when the action of the heart itself fails, &c.

[r] Observe, for instance, in Walter's *Tabulæ nervor. thorac. et abdominis,* the right hepatic, tab. ii. O. tab. iii. *l.*—the splenic, tab. ii. P., tab. iii. *m.*, tab. iv. *o.*—the superior mesenteric, tab. ii. Q., tab. iii. *f.* — the inferior mesenteric, tab. ii. T. —and many others.

Consult Soemmerring, *De c. h. fabrica.* t. iv. p. 362.

[s] Haller, *De Nervor. in arterias imperio.* Gotting. 1744. 4to.

Lucæ, l. c.

[t] T. Kirkland, *Inquiry into the present state of Medical Surgery.* London, 1783. 8vo vol. i. p. 306. sq.

But especially Cal. Hillier Parry's *Experimental inquiry into the arterial pulse.* Lond. 1816. 8vo.

131. Since Whytt,[u] especially, and other illustrious physiologists have been convinced that the influence of the heart could not reach the extreme arteries and the origins of the veins, they have ascribed the progression of the blood in those vessels to a kind of *oscillation*, and have happily employed this to demonstrate the nature of inflammation.

Many kinds of phenomena, both physiological, as those regarding animal heat, and pathological, as those observed in spasms and particularly in fevers, favour the supposition of this oscillatory faculty, but it is not demonstrable during life to the eye, even aided by glasses. (H)

132. It remains for us now to examine the aid given to the returning blood by the *veins*, their radicles not being taken into the account. We should conclude at first sight that they have far less active power[x] than the rest of the sanguiferous system, and that the return of their purple blood to the heart is chiefly ascribable to the impetus a tergo of the arterial blood, and to their valvular structure which prevents any reflux. The efficacy of the valves in this point of view, is shown by the distensions and infarctions of the veins in the lower part of the abdomen, which are found destitute of valves.[y]

The existence of vital powers in the venous trunks is probable,[z] from the example of the liver and placenta (127), and from experiments instituted on living animals. We formerly mentioned the muscular layer in the extreme veins near the heart (95). (I)

[u] Consult his *Physiological Essays, containing an inquiry into the causes which promote the circulation of the fluids in the very small vessels of animals.* Second edition, Edinb. 1761. 12mo.

H. v. d. Bosch, *über das Muskelvermögen der Haargefässgen.* Munster, 1786. 8vo.

[x] What is commonly, but improperly, called the *venous pulse*, observable on opening living animals, and in some morbid affections, and also under a violent effort, does not correspond with the action of the heart, but with respiration; since, if an expiration is unusually deep and lengthened, and the reflux of the blood to the lungs thus impeded, the jugular vein swells as far as the brain, the subclavian as far as the basilic, and the inferior cava as far as the crural.

[y] G. E. Stahl, *De vena portæ porta malorum.* Halæ, 1698. 4to.

[z] Lister, *De humoribus*, p. 25.

133. These are the chief powers which move the blood and depend upon the structure and vitality of the sanguiferous system. We say nothing of the effect of gravity, attraction, and other properties, common to all matter. The more remote assistance derived after birth from particular functions, *v.c.* respiration and muscular motion, will appear in our account of those functions. (K)

NOTES.

(A) On applying the ear or a stethoscope to the region of the heart, the distinct sounds of the action of the ventricles and auricles may be at once perceived. At the moment of the arterial pulse is heard a dull sound, and immediately afterwards, without any interval, a clearer sound, similar to the noise of a valve or to the licking of a dog. The former arises from the action of the ventricles, the latter from that of the auricles.

The former occupies about $\frac{2}{4}$ of the whole time; the latter $\frac{1}{4}$ or $\frac{1}{3}$, and then a pause occurs of another $\frac{1}{4}$. This is termed the *rhythm* of the heart's action.[a]

The *sounds* of the heart are ordinarily heard in health between the cartilages of the fourth and seventh ribs, and under the inferior part of the sternum; those of the left side of the heart in the former situation, and those of the right in the latter.

The *shock*, or *stroke*, occurs, as mentioned in the text, at the contraction of the ventricles. The force and extent of the sound and of the shock, and the rhythm of the heart's action, are variously altered in disease, and other sounds superadded.

(B) Dr. W. Hunter accounted for this in 1746.

" The systole and diastole of the heart, simply, could not pro-

[a] See the lamented Dr. Laennec's most admirable work, *Traité de l'Auscultation Médiate, et des Maladies des Poumons et du Cœur.* 2d edit. 1826. t. ii. p. 403. sqq.

duce such an effect; nor could it have been produced, if it had thrown the blood into a straight tube, in the direction of the axis of the left ventricle, as is the case with fish, and some other classes of animals: but by throwing the blood into a curved tube, viz. the aorta, that artery, at its curve, endeavours to throw itself into a straight line, to increase its capacity; but the aorta being the fixed point against the back, and the heart in some degree loose and pendulous, the influence of its own action is thrown upon itself, and it is tilted forwards against the inside of the chest." [b]

Though this is generally allowed, Haller remarks that in the frog also, which has a straight aorta, the point of the heart moves forwards during the contraction; [c] and some say that while the heart of a dog continues to palpitate, after being extracted from the chest, the apex is lifted up at each contraction of the empty ventricles. [d]

The occurrence is ascribable likewise, in some measure, to the distension of the auricles, for Haller found the apex give the usual stroke at the nipple, on his distending the left auricle with air, [e] and Senac [f] has shown a similar influence from the right auricle also.

Dr. Barclay has the following passage on this point:

" When the blood is forced into the arteries, their curvatures, near where they issue from the ventricles, are from their distension lengthened and extended towards straight lines; and, causing the heart to palpitate in their motions, compel it to describe the segment of a circle, when the apex moving atlantad and sinistrad, is made to strike against the left side. The same kind of motion having also been observed by the celebrated Haller, in distending the left or systemic auricle, it must follow, that the stroke which is given to the side, may be the effect of two distinct causes, either acting separately, or in combination: but acting on a heart obliquely situated, as ours is, in the cavity of the thorax, where the aspect of the base is atlantad and dextrad, and that of the

[b] *Treatise on the Blood*, &c., by John Hunter, p. 146. Note.

[c] *El. Physiol.* t. i. p. 394.

[d] Mr. H. Mayo, *Outlines of Human Physiology*. 1827. p. 68.

[e] l. c. ibid. where he refers to Senac and Ferrein.

[f] *Traité du Cœur*, p. 357.

apex sinistrad and sacrad. In combination, as the first of the two, by removing the pressure, will facilitate the influx of the venous blood into the left or systemic auricle, which is situated dorsad; so the second, by the influx of blood into the auricle, will contribute in its turn to facilitate the circular motion of the heart, proceeding from the arteries."[g]

(C) It is commonly believed, that the pulse of every person is quicker in the evening than in the morning, and some have supposed an increase of quickness also at noon. Upon these suppositions Dr. Cullen builds his explanation of the noon and evening paroxysms of hectic fever,[h] as others had theirs of the evening exacerbation of all fevers,[i] regarding them as merely aggravations of natural exacerbations. The existence of the noon paroxysms is doubtful, and the evening one cannot be so explained if Dr. R. Knox is correct,[k] though he is opposed to Haller, &c. His observations make the pulse to be slower in the evening, and quicker in the morning.

Dr. Heberden saw a woman fifty years of age who had always an intermitting pulse, yet an able anatomist could discover nothing unusual after death; and two persons whose pulse was always irregular in strength and frequency when they were well, and became quite regular when they were ill.[l]

(D) The heart, however, of frogs, for instance, contracts and relaxes alternately, for a length of time, when out of the body and destitute of blood.

Mr. Brodie divided the great vessels in rabbits and found the action of the heart "apparently unaltered, for at least two minutes after that viscus and the great blood-vessels were empty of blood."[m] But the quantity of blood greatly influences the action of the heart.

(E) The influence of a vacuum, pointed out by Rudiger,[n] enlarged upon by Dr. Andrew Wilson, and mentioned as probable

[g] *The Muscular Motions of the Human Body,* p. 567.

[h] *Practice of Physic.*

[i] Haller, *El. Physiol.* t.ii. p.263.

[k] *Edinburgh Medical and Surgical Journal.* 1815.

[l] *Transactions of the College of Physicians.* London. vol. ii. p. 31.

[m] Dr. Cooke, *A Treatise on Nervous Diseases,* vol. i. p. 63.

[n] Quoted by Haller, *El. Physiol.* t. ii. lib. vi. p. 325.

by Haller,[o] John Hunter,[p] &c., has been very ably displayed by Dr. Carson of Liverpool.[q]

The quantity of the blood, the length of its course, and the various obstacles opposed to its progress, render, in his opinion, the mere propulsive power of the heart insufficient to maintain the circulation perpetually. But assistance must be given by the vacuum which takes place in all the cavities of the organ, when the contraction of the muscular fibres is over. The blood is thus drawn into each relaxed cavity, and the heart performs the double office of a forcing and a suction pump. The situation of the valves of the heart is thus explained. There are valves between the auricles and ventricles, and at the mouths of the two great arteries, because behind each of these four openings is a cavity of the heart, alternately dilating and affording a vacuum, into which, were there no valves, the blood would be drawn retrograde. At the venous openings of the auricles no valves exist, because they do not open from a cavity of the heart, — from a part ever experiencing a vacuum, and, therefore, the blood cannot, when the auricles contract, move retrograde, but will necessarily pass forwards into the ventricles, which at that moment are offering a vacuum. The inferior elasticity and irritability of the veins are also explained. If veins were capable of contracting equally with arteries, on the diminution of their contents, the suction influence of the heart would constantly reduce their cavities to a smaller capacity than is compatible with their functions. The collapse of the veins by pressure, during the suction of the heart, is prevented by the fresh supply of blood afforded by the vis a tergo, which does exist, although it is not

[o] "Sanguinem in auriculam dextram, tanquam in *vacuum* castellum approperare, ne id quidem videtur absque specie veri dici." l. c. An idea of the same kind appears to have been entertained before the time of Rudiger, whose work, *De regressu sanguinis per venas mechanico*, was published at Leipsig in 1704. For in Pecquet's *Experimenta nova Anatomica*, published in 1651, arguments are adduced against those who conceived that the diastole sucked the blood towards the heart, ("num, ut quibusdam placuit, ATTRAHENDO pelliciat EXUGATVE, investigandum." Chap. vii. sqq.) At that time suction was not generally known to be merely a means of removing or diminishing the resistance to the pressure of air, but supposed to be an occult principle. He details experiments to show its true nature, but urges nothing against suction in the proper acceptation of the term, and his adversaries were right in their fact, though ignorant of its true nature.

[p] *A Treatise on the Blood*, &c. p. 185.

[q] *An Inquiry into the Causes of the Motion of the Blood*. 1815.

considered by him as of itself adequate to convey the blood back to the right auricle.

All allow that when the heart is relaxed its cavities enlarge, though some ascribe this to its elasticity, and others regard it as a necessary consequence of the arrangement of its fibres.[r] Experiment proves the same. Dr. Carson extracted the hearts of some frogs, and immediately put them into water, blood-warm. They were thrown into violent action, and, upon some occasions, projected a small stream of a bloody colour through the transparent fluid. The water could not have been projected unless previously imbibed. It was thought that a stream of the same kind continued to be projected at every succeeding contraction; but that, after the first or second, it ceased to be observable, in consequence of the liquid, supposed to be imbibed and projected, losing its bloody tinge and becoming transparent, or of the same colour with the fluid in which the heart was immersed. The organ was felt to expand during relaxation, — a fact stated long ago by Pechlin.[s]

Dr. Carson accounts, however, for the full dilatation of the heart upon another principle, upon the consideration of which it will be impossible to enter before the next section, where the subject will therefore be prosecuted.

(F) Most physiologists grant to the capillaries irritability, tonicity, or organic contractility; but some deny that *arteries* possess muscular properties. Bichat's objections are, the absence of contraction on the application of stimuli to them, the much greater resistance of the middle coat to a distending force than of muscular parts, and, lastly, the difference of the changes which it and muscles undergo both spontaneously and by the action of other substances.[t] Berzelius has multiplied the latter description of proofs.[u] However this may be, I must remark, first, that the capillaries have certainly vital powers of contraction as fully as any parts of

[r] The heart was shown by Dr. Alexander Stewart, about the beginning of the last century, to be resolvable by boiling water into a semicircular muscle, with all its fibres running parallel to the base. Being rolled round in a funnel form, the left ventricle is produced, and the second turn produces the right, by the space between it and the first layer. The walls of the left ventricle, except the septum, are strengthened by an additional convolution, which the right ventricle has not. The auricles are distinct, and by boiling drop off from the ventricles. *Phil. Trans.* vol. ix. abridg.

[s] *De Corde.* [t] *Anatomie Générale,* t. ii. [u] *Animal Chemistry,* p. 25.

the body. This appears in their various degrees of *local* dilatation and contraction, under inflammation, passions of the mind, &c. When different stimuli are applied to them, they are seen under the microscope locally to experience various degrees of contraction and dilatation, and this even after connection with the heart has been cut off by absolute excision of this organ.[x] Under similar circumstances, when no stimulus was applied, the blood was seen by Dr. Hastings often to cease, indeed, to flow, but still to oscillate. If the capillaries are allowed to possess organic contractility, it is impossible to say in which point of the arterial tract it begins.

The evidence of muscular fibres is not necessary to irritability. The iris and uterus are strongly endowed with irritability, but their muscularity is disputed by many. No muscularity is discernible in the plant called dionœna muscipula, nor in the sensitive plant, nor in those zoophytes which appear gelatinous masses, yet contractility dependent on life is very manifest in them.

Verschuir actually found the larger arteries contract on irritating them with a scalpel, in fifteen out of twenty experiments.[y] Dr. L. Bikker, and J. J. Vandembos assert the same of the aorta, and Van Geuns of the carotid when influenced by electricity.[z] Zimmerman, Bichat, and Magendie, saw the arteries contract upon the application of acids, but the two last considered it a chemical change. Dr. Hastings, however, saw the same from the application of ammonia. J. Hunter found the posterior tibial artery of a dog contract so as nearly to prevent any blood from passing through it on merely being laid bare, and facts similar to this are mentioned by Drs. Hastings, Fowler,[a] Jones,[b] and the Drs. Parry. The fact of continued contraction, and of alternate contraction and relaxation in arteries, being occasioned by stimuli is therefore certain, and although some have not succeeded in stimulating them, we must remember that others have failed in the application of electricity to parts indisputably muscular; — Verschuir[c] in the

[x] See Dr. Wilson Philip, *On Febrile Diseases;* Dr. Thomson, *Lectures on Inflammation;* Dr. Hastings, *A Treatise on the Inflammation of the Mucous Membrane of the Lungs.* 1820.

[y] *De Art. et Ven. vi Irrit.*

[z] See Hastings, l. c. The introduction to this work is a body of information on the present subject.

[a] *Disputatio inauguralis de Inflammatione.*

[b] *On Hæmorrhage.*

[c] l. c. expt. 22.

case of the heart and urinary bladder, and Zimmerman in other parts of known muscularity.[d] Dr. Hastings caused contraction in veins also by the application of stimuli.[e]

Dr. Parry instituted a number of experiments upon this question. After exactly ascertaining the circumference of arteries in animals, he killed them, and again measured the circumference; and after a lapse of many hours, when life must have been perfectly extinguished, he measured the circumference a third time. Immediately after death, the circumference was found greatly diminished, and on the third examination it had increased again. The first contraction arose from the absence of the blood which distended the vessel and antagonised its efforts to contract, and it was evidently muscular, or to speak more correctly, organic, contraction, because, when vitality had ceased, and this kind of contraction could no longer exist, the vessel was, on the third examination, always found enlarged.[f]

The forced state of distention in arteries was proved by the contraction immediately occurring on making a puncture in a portion of vessel included between two ligatures. An experiment of Magendie's is of equal weight, in which a ligature was fixed on the whole of a dog's leg except the crural artery and vein, and the vein and artery were compressed, when, upon wounding the vein, the artery completely emptied itself.[g] The capacities of arteries are thus always accommodated to the quantity of blood, and this circumstance gives the arterial canal such properties of a rigid tube as enable an impulse at the mouth of the aorta to be instantly communicated throughout the canal. This appears the great office of the contractile powers of arteries, for,

(G) They do not incessantly dilate and contract to any amount, as many imagine. Dr. Parry, on the most careful examination, could never discover the least dilatation in them, during the systole of the ventricle, — when the pulse is felt. Dr. Hastings declares he has seen it, as does Magendie in the case of the aorta and carotid of the horse; but from the number and accuracy of Dr. Parry's experiments, I incline to believe it does not occur in the ordinary undisturbed state of the circulation to any extent. Dr. Barry plunged his arm into the thorax of a horse and found the aorta constantly full, nearly to bursting, not perceptibly vary-

[d] *De irritabilitate.* [e] l. c. p. 52. sq.

[f] See also J. Hunter, *On the Blood*, p. 114. 116.

[g] *Journal de Physiologie*, t. i. p. 111.

ing in distention for an instant, though he held it during five minutes and examined it afterwards again; while at every expiration the cava was so empty as to feel only like a flaccid thin membrane.[h] The fact of a continued stream occurring from a *wounded* artery, only augmented at each pulsation of the heart, is thought by Magendie[i] to prove that the arteries assist in propelling the blood: but an opening takes off the resistance to its course so considerably that the vessel cannot but contract between the impulses of the heart.

Although the blood is constantly streaming onwards, the pulse is felt only when arteries are more or less compressed; under which circumstance, the motion of the blood onwards, by the impulse of a fresh portion from the left ventricle, is impeded: and this effort of the fluid against the obstructing cause gives the sensation called the pulse,[k] which follows the stroke of the heart successively later throughout the arterial system, though the interval is in general too minute to be appreciated. Dr. Barry found no pulsation in the aorta of the horse, unless he compressed it violently.

The elastic coat both assists and antagonises the muscular: assists it in preventing distention when the distending force is very strong, and antagonises it — tends to prevent the canal from becoming too narrow, when it attempts to contract the vessel excessively.[l]

Still, independently of the whole quantity of blood, and of the heart's action, particular arteries may be in various degrees of distention, according to the various states of their individual contraction. For example, when a finger has a whitlow, the

[h] *Dissertation sur le passage du Sang à travers le Cœur.* Paris, 1827. p. 78. Also, *Annales des Sciences Naturelles,* June 1827.

[i] *Journal de Physiologie,* t. i. p. 110.

[k] *An Experimental Enquiry into the Nature, Causes, and Varieties of the Arterial Pulse,* &c., by Caleb Hillier Parry, M.D. F.R.S. 1816. Likewise a second work, entitled, *Additional Experiments on the Arteries of warm-blooded animals,* &c., by Chas. Hen. Parry, M.D. F.R.S. 1819. — the latter displays as much talent and learning as the former of originality. Dr. Young, in a Croonian lecture, highly worth perusal, on the functions of the heart and blood-vessels, reasons to prove that the muscular power of arteries has very little effect in propelling the blood. *Phil. Trans.* 1809.

[l] On the operation of the elastic and muscular coats, see Hunter, l.c. p. 118. sqq.

digital branches are found larger than usual at the very roots of the fingers; in many affections the pulse of the two wrists differ for a time. In fact, their condition may vary like that of the capillaries, and probably does vary every time that altered circulation occurs in a part, although Dr. Parry's opinion holds true during the tranquil and ordinary condition of circulation. I am thus inclined to agree with and differ from both Dr. Parry and Dr. Hastings; believing the former to be right as to the ordinary state, the latter in irregularity.

The elastic power is said to be greater in the arteries, and the muscular in the capillaries; and as the muscular power is proved by Dr. Parry's experiments to be able to overcome the elastic in the arteries, it must be very considerable in the capillaries.

Dr. Curry, the late senior physician and distinguished lecturer on the practice of medicine at Guy's Hospital, concluded, without doubt hypothetically, from some microscopic experiments which he had made on inflammation in the presence once of Mr. Charles Bell and once of Mr. Travers, that the circulation is indispensably facilitated by a sort of electric repulsion between the vessels and their contents, and that in inflammatory accumulation, the tone of the vessels being impaired, this repulsion is diminished and the blood passes onwards with difficulty in consequence.[m]

(H) These oscillations are quite imaginary, and now disallowed. Although variations of dilatation must affect the course of the blood through vessels, it is difficult to conceive how any regular action of them can assist it, while the blood is propelled and drawn by the heart; and the influence of the heart was seen by Dr. Hastings in some microscopical experiments, in which partial obstruction was produced, to extend to arteries, capillaries, and veins, as the blood in them all received a sensible impulse at each contraction of the ventricles. Indeed we have ocular proof that the capillaries do not contract on the blood in the ordinary state of things, for the blood in them, as well as in the arteries and veins, may be seen for an hour together in the frog's foot, under the microscope, to move in a stream unvarying, — neither becoming finer alternately nor experiencing impulses.[n]

[m] See the *Syllabus* of his lectures for 1810.

[n] Hastings, l. c. p. 46. sq. Magendie, *Journal de Physiol.* t. i. p. 107. sq., says that the blood streams in the arteries and veins of cold-blooded animals, as if the vessels were motionless.

In fœtuses without hearts,[o] it is not proved that the vascular system carries on the circulation by its own power, because a twin without a heart has never been seen unless accompanied by a perfect fœtus, whose heart might circulate the blood of both; for the placentæ often communicate, so that one child has died of hæmorrhage from the chord of the other: and in the only case where the matter was ascertained,[p] the akerious fœtus was actually injected by the navel-string of the perfect fœtus.[q] When, however, the blood is not moved by the heart, the capillaries do impel it. Dr. Wilson Philip once saw it moving freely in some mesenteric capillaries of a rabbit for an hour and a quarter after the excision of the heart;[r] and Haller and Bichat made similar observations.

Mr. Burns,[s] anxious to prove that the arteries are of more importance than the heart, that they themselves circulate the blood which they receive,[t] and that the auricles are of more importance than the ventricles, mentions, among other examples of diseased heart, one in which both ventricles were as completely ossified as the cranium, except about a cubic inch at the apex, and in which there had been no palpitation or pain in the heart. As bony ventricles could not contract, nor easily be moved, palpitation could not readily have occurred, and pain rarely attends the ossification of any part. That the circulation was deranged is proved by the woman having experienced great dyspnœa, and expectoration, and dropsy. The auricles were healthy and thicker than usual, and had evidently performed the duty of the ventricles, through which, as an unchanging reservoir between the auricles and the pulmonary artery and aorta, the auricles drove the blood. The invariable languor of circulation in cases where the action of the heart is languid, proves the power of the heart in the circulation.

On the other hand, the large arteries of the extremities are continually found ossified without any apparent deficiency of circulation. I have seen long tracts of vessels in the lower ex-

[o] Hewson, *Exp. Enquiry*, v. ii. p. 15. Mr. Brodie, *Phil. Trans.* 1806.

[p] *Phil. Trans.* 1793. p. 155.

[q] Dr. Young, *Introduction to Med. Literature*. 1823. 2d edit. p. 631. sq.

[r] *An Experimental Enquiry into the Laws of the Vital Functions*. 3d ed. expt. 67.

[s] *Observations on some of the most frequent and important Diseases of the Heart*, &c. By Allan Burns. 1809. p. 117. sqq.

[t] l. c. p. 120.

tremities ossified, where no such circumstance had been suspected. Mr. Burns himself mentions an instance "of the arteries of the head, pelvis, legs, and arms, being almost entirely ossified,[u]" the heart and aorta being healthy; and yet the man clearly died of diseased liver induced by hard drinking, hot climate, &c.

The ventricles are certainly of more importance than the auricles, because these are absent in many animals, and are only reservoirs to supply the ventricles.[x]

(I) In a young lady whom I attended for chronic bronchitis accompanied by violent cough, and who ultimately recovered, *all* the veins of the back of the hands and fore-arms distinctly pulsated synchronously with the arteries. An universal pulsation of the veins synchronous with that of the arteries, occurred for some days twice in a young man who died of cerebral disease, with constriction of the mouth of the aorta;[y] once in a middle-aged man with affections of the head and abdomen, who recovered;[z] once in a middle-aged man who died with dropsy and palpitation,[a] and lately in a girl who died with symptoms of hydrocephalus.[b] In a case of epidemic fever, the same was observed by Weitbrecht for twenty-four hours;[c] and he had previously seen a similar case, but doubted his senses. Haller's remark upon it is, "Ego quidem non intelligo."[d]

In venesection at the bend of the arm I have frequently seen the jet regularly stronger at each pulsation of the heart, and Hunter mentions the same thing, and states it to be more observable at the head or foot, saying, "The fact is, however, that there is a pulsation in the veins."[e]

Yet ordinarily there is, speaking of the veins in general, no venous pulsation, and the stream in the veins, though caused mainly by the left ventricle, — as may be seen by tying all the vessels of an extremity but the artery, and wounding the vein, when the jet from the vein may be regulated by pressing the artery,— is perfectly uniform. By the infinite subdivisions and great increase of ca-

[u] l. c. p. 124. sq.
[x] Hunter, l. c. p. 138.
[y] *Journal Complimentaire*, t.21. June, 1825.
[z] *Journal der Praktischen Heilkund.* Sept. 1815.
[a] *Archiv. für Medinische Erfahrung.* July and August, 1822.
[b] *Dublin Hospital Reports*, vol. iv.
[c] 1736. Haller's *Disputationes*, t. v. p. 407.
[d] *El. Phys.* t. ii. p. 356.
[e] l. c. p. 186. sq.

pacity of the arterial system, the blood which is moved in jerks in the larger arteries, giving a pulse, and, if the vessel is wounded, flowing more forcibly at the heart's pulsation, gives no pulse in the small vessels, and, if they are wounded, flows regularly; and in the capillaries, through the augmentation of space, experiences no increased momentum at the heart's pulsation. When the capillaries unite into veins, and the capacity of the whole vascular channel diminishes, the blood moves more quickly again through the diminished space;[f] but though the smaller space augments its flow again, the impulses of the heart lost in the capillaries cannot be felt in the veins, and the current in them is smooth. Neither, generally speaking, is it by any means so rapid as in the arteries, because much of the heart's force is expended, and the veins are generally so much more numerous than the arteries, and the space therefore, however less than in the capillaries, still much greater than in the arteries. Neither ought the momentum to be strong when the veins have all united into the cavæ, because it has only to reach the heart where there is no resistance, but, on the contrary, more than one source of vacuum prepared; whereas in the aorta it ought to possess a force sufficient to carry it a great distance, and surmount great obstacles.

When the veins have pulsated, the action of the heart must have been very violent, or some obstruction occurred, which, in Dr. Hastings's experiments, was seen to cause the heart's action to be sensible in the capillaries and veins.[g]

There is always a pulsation in the large veins near the heart, as we shall see when considering respiration, but that arises from a different circumstance.

The heart of *mammalia* and *birds* has no peculiarity necessary to be mentioned here. In most *amphibious animals*, the arteries of the system as well as of the lungs spring from the right ventricle, with which the left, that sends off no vessel, communicates: hence their circulation continues under water. In *amphibious mammalia* and diving birds, some vessels, especially one vena cava, are dilated to form a receptacle during the suspension of respiration. The heart of *fish* is extremely small, and has but one auricle and ven-

[f] Dr. Hastings, when observing the circulation in the frog's foot under the microscope, saw that the blood moved "faster in the arteries than in the veins, and in the veins than in the capillaries." l. c. p. 47.

[g] l. c. p. 47. sqq.

tricle, the latter propelling the blood to the gills, from which it streams to the system through a large artery. Neither blood-vessels nor absorbents have been discovered in *insects*, yet a large tube, close throughout, pulsates in their back; and Professor Carus has lately discovered a circulation in them through a granular substance. With respect to the *mollusca:* the cuttle fish has three detached hearts, consisting of a ventricle only, two for the gills and one for the aorta; the rest have a simple heart, the blood of the cava passing through the gills before it reaches the heart. The same is the case with the *crustacea*, and their heart has no auricle. *Worms* have circulating vessels distinctly contracting and dilating, but no heart, and their veins communicate with the general cavity of the body, and probably absorb. *Zoophytes* have no heart, nor circulating system, properly so called. In the echinus, indeed, there are two vessels that run along the intestines, and are thought to be an aorta and vena cava.

Vegetables have no central organ of circulation. The sap rises in tubes, called *common vessels*, up the wood, is distributed in thin minute ramifications over the surface of the leaves, experiencing changes by its exposure to air and light, and descends through other tubes, called *proper vessels*, in the inner layer of bark, affording the various peculiar secretions of the plant. The power of the *common vessels* is such, that if a piece of the stem is cut out, they entirely empty themselves; and the sap has been found to flow from the extremity of a branch with a force sufficient to overcome a column of water 43 feet $3\frac{1}{3}$ inches in height.[h]

(K) It would not be right to terminate this section without a note upon the discovery of the circulation of the blood; — a truth of which the ancients are thought to have remained ignorant, from finding the arteries empty after death; but it was known that these contained blood during life.[i] The discovery was made by our countryman, Dr. Harvey, Physician to St. Bartholomew's Hospital, and promulgated by him, at the age of forty-one, in an anatomical and surgical course of lectures at the College of Physicians, in 1619. He is entitled to the glory of having made it, says Hume,[k] "by reasoning alone, without any mixture of

[h] Hales, *Statical Essays*, vol. i. p. 101.

[i] Galen *De Anat. Admin.* vii. 15., where are some amusing anecdotes of his pupils and some persons who promised to prove the arteries empty.

[k] *History of England*, ch. 62.

accident." He informed Boyle, that he was led to it by reflecting on the arrangement of the valves of the heart and veins, as exhibited by his master Fabricius. Nothing, he knew, was planned in vain, and they clearly allowed a fluid to pass but one way. By this argument, and the fact of a ligature upon an *artery* causing the blood to accumulate in it on the side *nearest* the heart, and, upon a *vein*, *beyond* the ligature; and that animals bleed to death by wounds in arteries or veins, he chiefly established his doctrine. After his time it was demonstrated with the microscope in cold-blooded animals. His immediate reward was general ridicule and abuse, and a *great* diminution of his practice;[l] and no physician in Europe who at the time had reached forty years of age, ever, to the end of life, adopted his doctrine of the circulation of the blood.[m] When the truth could be denied no longer, he was pronounced a plagiarist; the circulation was declared to have been known to Plato, nay, more, to king Solomon.[n] The circulation through the lungs had certainly been imagined by Servetus, a Spanish physician, who was slowly burnt to death by Calvin for not being of the same opinion as himself upon a point in divinity.

[l] This he laments in a letter to a friend, as may be seen in a MS. of the Royal Society, referred to in the life prefixed to the College edition of his works: — "Quod multo rarius solito ad ægros invisendos accersitus esset, postquam librum de motu cordis ediderit."

[m] Hume, l. c.

[n] See Haller, *El. Physiol.* t. i. p. 243.

SECT. VIII.

OF RESPIRATION AND ITS PRINCIPAL USE.

134. The *lungs*,[a] closely connected with the heart both by proximity and by relation of function, are two viscera, large after birth, so light as to swim in water, and composed of a spongy, and, as it were, spumous, but pretty tenacious and elastic,[b] parenchyma.[c]

135. They fill each cavity of the chest, and are contiguous to the sacs of the pleuræ, to which, as well as to the other contents of the thorax, they model and apply themselves. (A)

136. They, in a manner, hang from the wind-pipe, usually called the aspera arteria, which, besides its interior coat always smeared with mucus, and the subjacent very sensible nervous coat, consists of another which is muscular, surrounding the latter, and divided, except posteriorly, by an indefinite number of cartilaginous falciform arches.

137. The aspera arteria, having entered the thorax, is bifurcated into the trunks of the bronchiæ, and these, the more deeply they penetrate into the lobes and lobules of the lungs, are the more and more ramified, losing both their cartilaginous rings and muscular coat, until their extreme divisions terminate in those *cells* which form the chief part of the substance of the lungs, and alternately receive and emit the air we breathe.

[a] Soemmerring and Reisseisen, *über die Structur, die Verrichtung und den Gebrauch der Lungen. Zwey Preischriften.* Berlin, 1808. 8vo.

[b] J. Carson, *On the Elasticity of the Lungs,* in the *Phil. Trans.* 1820. p. 29.
Consult also, Const. Ern. de Welzien, *De Pulmonum autenergia,* &c. Dorpat, 1819. 8vo.

[c] Respecting all the organs concerned in respiration, consult Corn. J. Van Den Bosch, *Anatomia Systematis Respirationi inservientis Pathologica.* Harlem, 1801. 4to. p. 1—44.

138. The shape and magnitude[d] of the air-cells are various. The former is generally polyedrical. The latter, in regard to surface, is scarcely to be defined:[e] though, indeed, the *capacity* of the lungs of an adult, during a strong inspiration, is about 120 cubic inches. The immense size to which the lungs may be inflated, when the chest has been opened, has no relation to our present subject.

139. The cells are invested and connected by the common but delicate mucous web — the general vinculum of the body, and must be carefully distinguished from it. In healthy and very recent lungs, I have found the cells so unconnected that they were distended in one insulated spot by air cautiously inflated into a fine branch of the bronchiæ, while neither the neighbouring cells nor the cellular membrane, which lies between the cells, admitted the smallest portion. If air is forcibly thrown in, the air-cells are ruptured and confounded with the cellular membrane, and both parts distended.

140. The mucous web surrounding the air-cells of the lungs is supplied with innumerable blood-vessels — divisions of the pulmonary artery and four pulmonary veins, the branches of which accompany the ramifications of the bronchiæ,[f] and, after repeated division, form at length an immense collection of most delicate and reticulated anastomoses. This extraordinary network, penetrating the mucous web on every side, closely surrounds the air-cells, so that the prodigious quantity of blood existing in the pulmonary vessels is separated from the contact of the air by very fine membranes only, which Hales estimated as scarcely $\frac{1}{1000}$ of an inch in thickness.

141. As each ramification of the bronchiæ possesses its own bunch or lobule of air-cells (139), so again each of these possesses a peculiar system of blood-vessels, the twigs of

[d] Keil, indulging his luxuriant iatro-mathematical genius, assigned more than 1,744,000,000 cells to each lung.

[e] Lieberkühn, with equal exaggeration, made the surface of the cells equal to 1500 square feet.

[f] Eustachius, tab. xxvii. fig. 13.

which anastomose in the wonderful net-work with one another, but scarcely at all with the blood-vessels of the other lobules, as is proved by microscopic observations on living frogs and serpents, by minute injections, and by the phenomena of vomicæ and other local diseases of the lungs. (B)

142. The common membrane investing the lungs is the chief seat of a remarkable net-work of lymphatic vessels[g] which run to numerous lymphatic or conglobate glands,[h] carefully to be distinguished from a neighbouring order of glands, called bronchial, that are supplied with an excretory duct and are of the conglomerate kind.[i]

143. The *thorax*, which contains the lungs, has an osseous and cartilaginous base, somewhat resembling a bee-hive, throughout very firm and stable, but in every part more or less movable for the purpose of respiration.[k]

This holds good chiefly with the six pairs of true ribs below the first, each of which is more movable than the one above in proportion to the greater length both of its own body and of its cartilaginous appendix. The cartilages are united by a kind of amphiarthrosis to the margin of the sternum on each side. (C)

144. Between the edges of the ribs lie two strata of intercostal muscles, differing in the direction of their fibres, but conspiring to produce the same motion.

At the base of the thorax, the diaphragm[l] is subtended in in the form of an arch. It is a considerable muscle, and, in the words of Haller, next in importance to the heart. Its utility in the mechanical part of respiration was long since

[g] Mascagni, *Histor. vasor. lymphaticor.* tab. xx.

[h] Ibid. tab. xxi.

[i] Consult Portal, *Mém. de l'Acad. des Scienc. de Paris.* 1780.

[k] J. G. Amstein (Præs. Oetinger), *De usu et actione musculor. intercostal.* Tubing. 1769. 4to. Theod. Fr. Trendelenburg, Jun. *De sterni costarumque in respiratione vera genuinaque motûs ratione.* Gotting. 1779. 4to.

Bordenave and Sabatier, *Mém. de l'Acad. des Scienc. de Paris.* 1778.

[l] Haller, *Icon. Anat.* fascic. 1. tab. i.

B. S. Albinus, *Tab. musculor.* tab. xiv. fig. 5, 6, 7.

J. G. Röderer, *De arcubus tendineis muscul.* progr. 1. Gotting. 1760. 4to. Santorini, Tab. Posth. x. fig. 1.

shown, by the excellent experiments of Galen[m] upon living animals, to depend chiefly on the phrenic nerve.[n]

Its antagonists are the abdominal muscles, especially the two sets of oblique and the transverse.

145. The thorax, thus constituted, is, after birth, dilated by inspiration, and subsequently reduced to a smaller capacity by expiration.

During the former act, the thorax is enlarged laterally and inferiorly, so that the bodies of the six ribs mentioned above (143) are elevated and their inferior margin drawn somewhat outwards; the arch of the diaphragm is at the same time rather depressed and flattened.

I have never observed the inferior extremity of the sternum, in the tranquil respiration of health, to be thrust forwards, as some have asserted. (D)

146. This alternate motion of the chest continues, during health and freedom from restraint, from the moment of birth till death. Its object is, that the lungs may be expanded to admit the air and contracted to expel it, in perpetual alternation. This alternation occurs, in an adult at rest, about 14 times in a minute, — once to about five pulsations of the heart.

147. For man, in common with all warm-blooded animals, cannot long retain the inspired air, but is compelled to discharge it and take in a fresh supply of this pabulum of life, as it always has been denominated.[o] Common observation teaches, that, however pure may be the air entering the lungs, it instantly undergoes remarkable changes, by which it is con-

[m] *De Anatomicis Administrationibus*, l. viii. cap. 8. The whole book is very rich in experiments on respiration.

[n] Ephr. Krüger, *De nervo phrenico*. Lips. 1759.; reprinted in Sandifort's *Thesaurus*. tom. iii.

Walter, *Tab. nervor. thorac. et abdominis*, tab. i. fig. 1. n. 1.

[o] The antiquity of the notion that air is the *pabulum vitæ*, is seen in the book *de Flatibus*, usually ascribed to Hippocrates. The author regards the aliment as three-fold, — victuals, drink, and air; but the latter he calls *vital*, because we cannot, for a moment, dispense with a supply of it without danger to life.

taminated and rendered unfit for another inspiration, unless it is renewed.[p]

148. It may be asked, what are the changes which the air experiences during inspiration, and which consist not in the loss of elasticity, as was formerly imagined, but in the decomposition of its elements.[q] For the atmospheric air, which we breathe, is a peculiar mixture of constituents, differing very much in their nature from each other; and, not to mention heterogeneous matters, such as odorous effluvia, various other besides aqueous exhalations, and innumerable other matters which are generally present, is always impregnated with aqueous vapour, electric and magnetic matter, and generally with carbonic acid gas; and is itself composed of unequal parts of two aëriform fluids, viz. 79 of azotic gas, and 21 of oxygen gas in 100.

149. In the first place we know for certain, that, at every inspiration (the fulness of which varies infinitely in different persons of the same age, breathing placidly[r]), besides the quantity of azotic gas being somewhat diminished[s], the oxygen gas is in a great measure converted into carbonic acid gas or fixed air; so that the air of expiration, if collected, instantly extinguishes flame and live coals, precipitates lime from lime water, and is specifically heavier than atmospheric air, and rendered unfit for inspiration[t]; it also contains much

[p] Consult Harvey's Dispute upon the necessary renovation of the aërial *succus alibilis*, with the celebrated Astronomical Professor, J. Greaves, in the latter's *Description of the Pyramids in Egypt*. p. 101. sq. Lond. 1646. 8vo.

Also the popular Edm. Halley's immortal *Discourse concerning the means of furnishing air at the Bottom of the Sea in any ordinary Depths.* — *Phil. Trans.* vol. xxix. No. 349. p. 492. sq.

[q] Fr. Stromeyer, *Grundriss der theoretischen Chemie*. P. ii. p. 619.

[r] Consult, *v. c.* Abildgaard, *Nordischen Archiv. für Naturkunde,* &c. t. 1. P. i. and ii.

[s] Consult, besides, Priestley and others, especially C. H. Peaff, ib. t. iv. P. ii.

[t] To discover how frequently an animal could breathe the same portion of the different kinds of air that we have mentioned, I took three dogs equal in size and strength, and to the trachea of the first, by means of a tube, I tied a bladder, containing about 20 cubic inches of *oxygen* gas. He died in 40 minutes.

aqueous vapour, which is condensed in a visible form by a temperature not exceeding 60° of Fahr.[u]

150. There is, consequently, no doubt that the carbonic acid of the expired air is derived from the venous blood carried to the lungs from the right side of the heart.[x] But it has been of late disputed, whether the inspired oxygen goes wholly to form carbonic acid in the bronchial cells,[y] or whether it is in part united with the arterial blood and distributed through the arterial system.[z] Many weighty arguments seem to favour the latter opinion, as well as the phenomena of both kinds of blood in the living body,[a] compared with the changes which this fluid experiences when exposed to these two kinds of air. (F)

151. This perpetual change of elements occurring in respiration after birth, we shall show to be very differently

---

For the second, the bladder was filled with *atmospheric* air. He died in six minutes.

For the third, I employed the carbonised air last expired by the second dog. He died in four minutes.

The air of the bladder, upon subsequent examination, gave the common signs of carbonic acid gas. (E)

The instruments which I employed are described and illustrated by a plate in the *Medic. Biblioth.* vol. i. p. 174. sq. tab. 1.

[u] J. A. De Luc, *Idées sur la Météorologie.* tom. ii. p. 67. 229.

[x] Rob. Menzies, *De Respiratione.* Edinb. 1790. 8vo.

H. G. Rouppe, on the same subject. Lugd. Batav. 1791. 4to.

J. Bostock, *Versuch über das Athemholen. übers. von* A. F. Nolde. Erf. 1809. 8vo.

[y] W. Allen and W. H. Pepys, *Phil. Trans.* 1808. p. 249. and 1809. p. 404. But how various the quantity of carbonic acid gas expired is, at different times of the day, and under different circumstances, is shown by the experiments of W. Prout, in Thomson's *Annals of Philosophy,* vol. ii. p. 328.

[z] Nasse in J. F. Meckel's *Archiv. für die Physiol.* vol. ii. p. 200.

And G. Wedmeyer, *Physiologische Untersuchungen über das Nervensystem und die Respiration.* Hanov. 1817. 8vo. p. 175.

[a] J. Andr. Scherer, *Beweis, dass J. Mayow vor* 100 *Jahren den Grund zur antiphlogistischen Chemie und Physiologie gelegt hat.* p. 104.

Edm. Goodwyn, *Connexion of Life with Respiration.* Lond. 1788. 8vo.

J. Hunter, *On the Blood,* p. 68.

J. A. Albers, *Beyträgen zur Anat. und Physiol. der Thiere.* P. 1. p. 108.

accomplished in the fœtus, viz. by means of the connection of the gravid uterus with the placenta.

But, when the child is born and capable of volition, the congestion of blood that takes place in the aorta, from the obstruction in the umbilical arteries; the danger of suffocation from the cessation of those changes of the blood, in regard to oxygen and carbon, (13) hitherto produced in the uterine placenta; the novel impression of that element into which the child, hitherto an aquatic being, is conveyed; the cooler temperature to which it is now exposed; and the many new stimuli which are now applied, seem to induce new motions in the body, especially the dilatation of the chest and the first inspiration.

The lungs, being for the first time dilated by inspiration, open a new channel to the blood, so that, being obstructed in the umbilical arteries, it is derived to the chest.

Since the inspired air becomes hurtful and unpleasant to the lungs by the decomposition which it experiences, I should ascribe to the most simple corrective powers of nature, the subsequent motion by which the poisonous mephitis, as it may be called, is expelled and exchanged for a fresh supply.

The consideration of all these circumstances, especially if the importance of respiration to circulation, demonstrated by the well-known experiment of Hooke [b], be remembered, will, in my opinion, explain the celebrated *problem* of Harvey, [c] better [d] than most other attempts of physiologists. (G) [e]

[b] It has the epithet Hookian, because it was most varied by Rob. Hooke. See Th. Sprat, *History of the Royal Society*. Lond. 1667. 4to. p. 232. But it was before instituted by Vesalius, and very much praised for its beauty. *De c. h. Fabrica*, p. 284.

[c] Wm. Harvey, *De circulat. sanguin. ad* J. Riolan. p. 258. Glasgov. 1751. 12mo.

And especially his *Exerc. de gener. Animalium*. p. 263. Lond. 1651. 4to.

[d] See Theod. C. Aug. Roose, *über das Ersticken neugebörner Kinder*, in his *Physiologisch. Untersuchungen*. Brunsw. 1796. 8vo.

J. D. Herholdt, *De vita, imprimis fœtus humani, ejusque morte sub partu*. Havn. 1802. 8vo.

[e] Consult, for example, Petr. J. Daoustenc, *De Respiratione*. Lugd. 1743. 4to. p. 54. sqq.

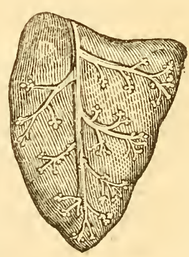
Rob. Whytt, *On the Vital and other Involuntary Motions of Animals*, p. 222. Edinb. 1751. 8vo.

NOTES.

(A) A correct notion can scarcely be formed from this description. The pleuræ are two closed sacs, one of which lies over each lung, one portion of the sac adhering closely to it, and one lying over this again ; the internal surfaces of both portions are always in contact, because, if the parietes of the thorax expand and draw with them the external portion, the lung at the same time expands with air and forces forwards the internal in the same degree. It is commonly said that a quantity of fluid (not vapour) exists in serous membranes for the purpose of lubrication. Dr. Marshal, from many experiments, believed that this is not the case, but that whenever fluid is discovered, we must regard it as the effect of either disease or the struggle of dying. His experiments were made on the ventricles of the brain, the theca vertebralis, the pleura, and the pericardium ; [f] yet, when Dr. Magendie has opened the membranes of the brain or spinal marrow, I have myself seen a colourless clear fluid instantly escape.

The serous membranes during life and health are translucent. M. Richerand tells us, that, on removing a portion of the thorax when cutting away a cancer, he saw the heart through the pericardium. [g]

(B) The best treatise with which I am acquainted upon the lungs, is the prize commentary of Reisseisen, published by the Royal Academy of Sciences at Berlin in 1808, and printed in 1822, with six beautiful coloured engravings, and a Latin version, under the care of Professor Rudolphi. [h]



He asserts, 1st. That the subdivisions of the bronchiæ occur more and more thickly, the twigs proportionally decreasing in diameter and length, and that each ultimate twig ends in a close bulbous extremity, or cell, communicating with other bulbous extremities only in an indirect manner, — by means of the twigs which end in them. Malpighi had described them as round, and mere dilatations

[f] *The Morbid Anatomy of the Brain in Mania, Hydrophobia, &c.*

[g] *Journal de Médecine.* 1818.

[h] Francis Daniel Reisseisen, M. D. of Strasburgh, *über den bau der Lungen, eine von der Königlichen Academie der Wissenshaften zu Berlin gekrönte Preisschrift.* Berlin, 1822.

in the course as well as at the ends of the bronchial twigs.[i] 2d. That, as Malpighi proved, and contrary to the subsequent opinion of Helvetius and others, these ramifications and cells have no connection with the surrounding common cellular membrane. 3d. That they consist of,—1. *mucous membrane*, behind which lies,—2. a coat of *elastic* white fibres, their existence being visible as far as the canals can be traced, and the regular discharge of any fluid injected into the bronchiæ after death proving the existence of elasticity in the bronchial ramifications;—3, a coat of *muscular* fibres, transverse relatively to the course of the canals, and visible by the aid of a magnifier as far as the size of the canals will allow them to be traced. He conceives the muscularity of the twigs and cells to be shown also from the necessity for its existence in them no less than in the large trunks and trachea, where it is visible; from their evident contraction in the experiments of Varnier, who irritated them by the injection of stimulating liquids and gases and by mechanically stimulating the surface of the lungs;[k] and from the circumstance of the lungs shrinking much more if an opening is made in the thorax of a living than of a dead animal, in the latter of which it can shrink from elasticity only. 4th. That the ramifications of the bronchial and pulmonary arteries freely anastomose both in the air-passages and on the surface of the lungs, and that the bronchial arteries run chiefly direct to the pulmonary veins. 5th. That the air-passages and blood-vessels of the lungs are most abundantly supplied with nerves from the par vagum, whose conjunctions with the sympathetic take place externally to the lungs.

Some other conclusions are drawn, but unimportant or unsatisfactory.

(C) Although each lower rib must execute a greater extent of motion from being longer than the one above, yet the first is asserted by Magendie to be absolutely more moveable than the second, the second than the third, &c.: and this because the first has but one articular surface, is articulated with but one vertebra, and possesses neither internal nor costo-transverse ligament and has the posterior ligament horizontal, and because slight shades of difference exist in the disposition of the ligaments of the six other ribs.[l]

[i] *Epist. de Pulmon.* 1. p. 133.

[k] *Mémoires de la Société Royale de Médecine.* 1779. p. 394. sqq.

[l] *Précis Elémentaire*, t. ii. p. 317.

(D) Dr. Carson gives the following account of the mechanical part of respiration.

The substance of the lungs is highly elastic, and constantly kept in a forced state of distention after birth by the pressure of the atmosphere.[m] This is evident also from the lungs collapsing upon our puncturing the walls of the thorax, — a circumstance arising from the atmospheric pressure on the one hand becoming counterbalanced on the other, so that their elasticity, experiencing no opposition, becomes effective.[n] During inspiration, the intercostal muscles raise and draw out the ribs, and the diaphragm descends: the enlargement of the thoracic cavity is instantly followed of necessity by the greater distention of the substance of the lungs from the diminished resistance to the atmosphere gravitating in the bronchiæ. The diaphragm and intercostal muscles ceasing to act, the substance of the lungs exerts its elasticity with effect, recovers its former dimensions, and drives out the additional volume of air just admitted, and the passive *diaphragm* follows the shrinking substance of the lungs, offering, from its relaxation, no resistance to the atmosphere pressing on the surface of the abdomen. Thus expiration is produced. The muscular power of the diaphragm and intercostal muscles is far greater than the elastic power of the lungs, and therefore, when exerted, overcomes it, producing inspiration: but, ceasing to be exerted, the elastic power gains efficiency, and produces expiration.

To the elastic, Reisseisen adds the muscular, contraction of the bronchial ramifications and cells. "Thorace ampliato, aër vacuum in pulmone spatium occupat, *victisque fibris*, fistulam spiritalem quaquaversum extendit, ultra modum, quo quiescit, explicari coactam, unde fibræ *elasticæ resilire*, circulares sese contrahere nituntur, quo fit ut desidente thorace omnes simul ad expellendum spiritum vires intenduntur. Sunt autem, thoracis undique desidentis pressio, tum fibrarum fistulam spiritalem in brevius contrahentium vis *elastica*, denique *muscularium* illam constringentium *irritabilitas*."

[m] See Haller, *El. Phys.* lib. viii. s. iv. p. 259. 275.

[n] Dr. Carson found the elasticity of the lungs of calves, sheep, and large dogs, balanced by a column of water of from a foot to a foot and a half in height, and of rabbits and cats by a column of from six to ten inches. *Phil. Trans.* 1820. Part 1.

"The contractile power of the diaphragm (*and intercostal muscles*) in conformity with the laws of muscular motion," says Dr. Carson [o], "is irregular, remitting, and sometimes altogether quiescent. The elasticity of the lungs, on the other hand, is equal and constant. The superior energy of the former is balanced by the permanency of the latter. By the advantage which the inferior power, from the uniformity of its operations, is enabled to take of the remissions of its more powerful antagonist, the ground which had been lost is recovered, and the contest prolonged; that contest in which victory declaring on one side or the other is the instant death of the fabric."

In the common account of respiration, the elasticity and muscularity of the lungs are unnoticed, and expiration is ascribed to the elasticity of the cartilages of the ribs, and to the contractions of the abdominal muscles emptying the lungs by pressure. Now, according to Dr. Carson, in the first place, the elasticity (*and muscularity*) of the lungs is of itself sufficient for the purpose; in the second, there is no proof of the agency of the abdominal muscles in expiration, — it proceeds equally well in cases of inanition, when their contraction would rather enlarge than diminish the abdominal cavity, and in experiments when they are entirely removed from animals, — a child was born without them, and had lived eighteen months at the time of the publication of its case, and was very well; [p]—and, I may add, thirdly, that, although the elasticity of the cartilages of the ribs must conspire with that of the lungs, numerous cases are recorded of immobility of the ribs, by ossification of their connections, where respiration was not materially impeded. [q] These cases are adduced to show that the diaphragm is the chief instrument of respiration; but as its elasticity cannot produce expiration, they show that this was accomplished entirely, or in a great measure, by the lungs themselves. Even where there is no ossification, the motion of the ribs has very little share in respiration, and Dr. Bostock considers the chief use of the intercostals to be that of giving a fixed point for the action of the diaphragm, and the operation of the abdominal muscles in expiration to be nearly passive. [r] It is commonly

[o] l. c. p. 223.

[p] *Gazette de Santé*, Dec. 5. 1826.

[q] Dr. Bostock, *An Elementary System of Physiology*, vol. ii. p. 15.

[r] l. c. vol. ii. p. 7. 15.

known, however, that if the pleura is wounded, air rushes into the chest during inspiration only, and is in some measure expelled again during expiration. Galen showed this, notwithstanding his object was different, by wounding the chest, and fixing a bladder upon the wound. The bladder shrunk at inspiration, and became distended at expiration.[s] Were the ascent of the diaphragm and descent of the ribs in expiration the *effect* of solely the contraction of the lungs,—of a tendency to vacuum occasioned by their shrinking,—air and fluids should stream to the chest as much during expiration as inspiration,—should rush to fill up the vacuum as much as the diaphragm should ascend and the ribs descend for that purpose: nor should air be expelled from the wounded pleura; for we may regard the thoracic cavity as bounded above by the surface of the lungs, and always in the sound state possessing the same dimensions,—the expansion of the lungs being commensurate with the descent of the diaphragm and ascent of the ribs, and the descent of the diaphragm and ascent of the ribs commensurate with the shrinking of the lungs. The fact that air does not stream into the wounded pleura in expiration, but even streams from it, while the ribs are moveable and the abdominal muscles active, proves, I think, that the descent of the ribs and ascent of the diaphragm, one or both, in ordinary expiration, do partly occasion, by compression,[t] the diminution of the lungs, or, at least, are not its passive effect, but coincide with it by independent powers,—which are, the elasticity of the elevated ribs (and displaced abdominal organs?) if not the contraction of the extended abdominal muscles. We shall presently see another reason for believing that the organs of the chest are really compressed during expiration. Haller refers expiration to the pressure of the lungs by the elastic ribs, and the abdominal and other muscles, and to the elastic and muscular contraction of the lungs themselves, which he considers more forcible than the compression. It appears to me that he is right; but that, nevertheless, either the lungs alone, or the walls of the chest alone,

[s] *Administ. Anat.* lib. viii. c. ult.

If, instead of a bladder, a tube immersed in a coloured fluid is employed, this will of course rise in inspiration, and remain stationary or fall in expiration. See *Experimental Researches on the Influence exercised by Atmospheric Pressure upon the Progression of the Blood in the Veins*, &c. By Edward Barry, M.D. London, 1826.

[t] l. c. lib. viii. sect. iv. p. 275. sq.

are able, when unassisted by the other, to produce expiration. The change in the situation of the ribs is, moreover, trifling compared to that of the diaphragm, and respiration often proceeds very well by the diaphragm alone. Animals which are remarkable for swiftness and perseverance in the race scarcely employ the intercostal muscles, using the diaphragm almost solely.[t]

The beautiful contrivance in the shape of the thorax deserves attention. By its being conical, every degree of motion in the diaphragm produces a greater effect on the capacity of the chest than could occur were it of any other shape.

The passage of the air into the cells may be distinctly heard on applying the ear to the corresponding part of the chest, and is called by Laennec the respiratory murmur. It is much louder in children, and in them the cells are far more numerous and small. Whence an equal portion of lung from an infant a few days old weighs fourteen times more than from a man of seventy.[u]

The elasticity and muscularity of the lungs are not sufficiently great to expel the whole of their air in expiration. Thus they remain constantly in a certain degree of distention.[x]

I now recur to the subject of the circulation of the blood, as promised in note (E) of the last section.

The vacuum constantly threatening in the chest, according to Dr. Carson, either from the shrinking of the lungs or the contraction of the inspiratory muscles, and I may add from the expulsion of blood from the ventricles of the heart, will evidently be prevented, not only by the falling of the ribs and the ascent of the diaphragm in the former case, and ingress of additional air into the bronchiæ in the latter, but also by the flow of venous blood into the auricles: for the venous blood, being subject to the full atmospheric pressure without the chest, will necessarily be driven into the chest to prevent a vacuum; the blood of the pulmonary artery and aorta is under the same circumstances, but the propelling force of the ventricles at one moment, and the action of their valves during their relaxation, prevent its retrogression. The atmospheric pressure on the blood-vessels creates a necessity for greater strength in the ventricles, as it impedes

[t] Dr. Carson. l. c. p. 226.

[u] Magendie, *Journal de Physiologie*, t. i. p. 81.

[x] Reisseisen. l. c. p. 23.

the progress of blood from the heart; but it also facilitates the return. Thus the smaller pressure on the heart acts, by the intervention of the blood, as an antagonist to its contracting fibres, assisting to dilate them when they become relaxed.

That the blood is drawn towards the heart during inspiration has been long acknowledged. "In my experiments," says Haller, "if you open the chest, abdomen, neck, or fore-extremities of an animal, and lay bare the great veins, the superior and inferior cava, the jugular, subclavian, brachial, or mammary, you will see the blood return to the heart *whenever the animal inspires*, and these veins recede some lines from it, become empty and pale, flat and bloodless:" — depleri, pallescere, explanari, exsangues fieri." [y] In the words of Dr. Magendie, sixty years afterwards, [z] "when the chest dilates, it inspires the blood of the cavæ, and successively that of the veins ending in them; much in the same way as it does the air into the trachea." Were Dr. Carson's account of respiration correct, as a vacuum would be threatening in the chest equally during expiration and inspiration, the shrinking of the lungs should occasion the blood to stream towards the heart as much during the one as the other, to fill up the vacuum. But this is not the fact, any more than, as we saw, that air rushes into the wounded pleura during expiration. The coincidence of the effect of inspiration on the venous blood, and, when the pleura is wounded, on the air,

[y] l. c. lib. vi. sect. iv. p. 333. 1760.

[z] *Journal de Physiologie*, t. i. p. 136. 1821. For the same reason, if a tube is placed in the jugular vein, the air rushes into it during respiration with a noise, and the ill effects of air in the heart occur. Magendie, l. c. p. 195. And if a large vein is opened in surgical operations, and any thing prevents the sides from collapsing, the air may rush in and destroy life, as happened a few years ago at Paris. l. c. p. 192. sqq. This may be shown also, by inserting a tube, immersed in a coloured fluid, into a large vein, when the liquid will rise during inspiration, and stop or descend during expiration. See Dr. Barry, l. c. who conceives another source of vacuum to the pulmonary veins and venous sinuses, by the distraction of their parietes during inspiration, p. 29. 1826. And *Dissertation*, &c. p. 13. sq. Still more recently, Dr. Barry has applied the barometer to the chest of a pigeon, a viper, a common snake, and a frog, and found the mercury descend during inspiration. When connected with the exterior of the pericardium of an eel, the mercury became concave each time that the heart retired from the pericardium, so that its pulsations could be counted, and also at every effort of the animal to open its gill-covers. *Sur l'application du Baromètre, &c. Annales des Sciences Naturelles.* Avril, 1827.

prevents us from supposing that inspiration affects the circulation merely by giving a free passage of blood through the lungs. " The great venous trunks of the head, neck, chest, abdomen, fore-extremities," says Haller, " swell *during expiration*, from the blood either being obstructed or retrograding, and at inspiration are emptied of it from its flowing freely to the heart."[a] Or, in the words of Magendie, " when the chest contracts, the blood is driven back into the cavæ by the pressure experienced by all the organs of the chest." That the blood does really retrograde during expiration, appears by an experiment of Magendie's, in which a hollow bougie was passed into the great veins as far as the cava, or auricle itself, and the blood flowed from its extremity during expiration.[b] This fact seems to show compression of the thoracic organs during expiration, and therefore is an additional argument that ordinary expiration is not the effect solely of the elastic and muscular shrinking of the lungs. Such, indeed, is the pressure of expiration, that the heart during it propels the blood more violently into the arteries, and even into the veins; and, on the other hand, less forcibly during inspiration.[c]

[a] l. c. ibid. [b] *Journal de Physiologie*, t. i. p. 136. Paris, 1820.

[c] Bordeu, *Du Pouls*, p. 324. quoted by Haller; and Bichat, *Recherches Physiol.* p. 223. See Magendie for the veins, *Journal de Physiol.* t. i. p. 138., and Tulpius. In violent efforts the chest is still more compressed, whence the blood accumulates without the heart in the veins, and is driven more forcibly from the heart to all parts. These may be made after expiration or inspiration, but for a very violent effort we usually inspire first, to afford a better fixed point, and to continue the effort longer than would be possible after expiration. Respiration is generally suspended and the glottis closed, but if the effort is made after an inspiration, the glottis need not be closed, provided the air is allowed to leave the chest very slowly.

In myself, a deep inspiration, not followed in due time by an expiration, causes the pulse in a few seconds to become suddenly slow for a few seconds, falling as much as five-and-twenty beats per minute, and even double this, if it has just become rapid by a deep and prolonged expiration : but, as the breath continues to be held, which may be done much longer than inspiration can be refrained from after expiration, as there is a supply of air in the lungs in the former case, and not in the latter,—(in the latter I can refrain for a quarter of a minute, and in the former for rather above a minute) — the pulse gradually resumes its former quickness; and when the breath can be held no longer, evidently grows more and more rapid and weak. The effects of refraining from expiration, are the same in me as of refraining from inspiration. Rapid respiration quickens the pulse, by drawing the blood more frequently to the heart, and, in my case, if very deep as well as rapid, the circulation through the head becomes so violent, that vertigo occurs, and between this and the rapidity of the pulse, I at length cannot count the latter.

A continuance in refraining to inspire after a violent expiration, of course almost suspends the circulation by depriving the heart of blood,[d] which is no longer drawn to the heart by inspiration, and has been squeezed out by expiration: a continuance in refraining to expire after a deep inspiration has the same effect, but more slowly. In both cases the blood is no longer drawn to the heart by inspiration, and does not experience those chemical changes in the lungs which are indispensable to its free passage through them; though, they being, in the former, filled with air, and empty in the latter, it can continue to pass through them much longer in the former.

And this leads me to observe, that the mere suspension of respiration impedes the circulation through the heart by causing obstruction in the lungs, and that, consequently, inspiration, by giving free passage to the blood through those organs will accelerate its course through the veins, independently of a vacuum; although the influence of the vacuum is shown by the effect of inspiration upon the contents of tubes inserted, not into the veins, but merely into the cavity of the pleura or pericardium. Whether respiration is suspended after an expiration or an inspiration, the effect is the same: — the blood accumulates in the lungs and right side of the heart, if the windpipe is tied, whether the lungs be empty or full at the time of the ligature; and therefore it is not merely the mechanical condition of the lungs that produces the obstruction in this case, as was once supposed, but the want of chemical changes.[e]

But for this consideration, the effects of the thoracic vacuum on the circulation might be overrated; and, indeed, that too high an estimate has been formed of it is very certain: for,

1. In the fœtus, and in animals which do not respire at all, or not by a thoracic vacuum, the vacua arising from the dilatation of the heart's cavities, and from its diminished bulk under contraction, only can occur.[f]

2. If we suspend respiration and prevent the influence of both sources of vacuum, the circulation continues till the want of chemi-

[d] My own pulse, if a deep expiration is made, and inspiration refrained from, becomes rapid and excessively feeble, and more and more so till I can hold out no longer.

[e] See Haller, l. c. lib. vii. sect. iv. p. 253.

[f] On connecting the barometer with the interior of the pericardium of an eel, Dr. Barry found the mercury move.

cal changes arrests it; and if the vena cava, or any great vein, is obstructed so as to cut off connection with the heart, it becomes distended with blood[g] coming up towards the heart; and if wounded between the ligature and the extremities, the blood flows, whatever the position of the animal, till death ensues.[h] In these cases no vacuum assists. If the pericardium is laid bare, so that no vacuum can occur, except that from the dilatation of the heart's cavities, and the trachea tied, the right ventricle swells enormously with the arriving blood,[i] — a fact not to be explained, even by the heart's own vacuum. The influence of the left ventricle upon the course of the blood in the veins, was also shown by Magendie, who firmly tied every part of a dog's leg, except the great artery and vein, and then tied the latter and wounded it below the ligature, when the blood was projected to some distance, and continued to be so, except when the artery was compressed; and as long as the circulation continued, the stream from the vein was regulated at pleasure by compressing or liberating the artery.[k] — If a turgid vein in the hand is compressed, it will not become empty above, as it should if suction from one or all of the three sources mentioned, were considerable; and the jet of blood from an artery was found by Hales to be greater during a deep inspiration,[l] (probably from the more abundant supply to the left side through the lungs,) showing the action of the ventricle to be proportionably greater than the power of the thoracic vacuum at the moment of inspiration to oppose the discharge of blood from it. Still the effects of the vacuum are such as we have seen, and it must lessen the labour of the heart.

The empty condition of the arteries after death, has been ascribed by Dr. Carson to the thoracic vacuum. He states, that if an animal is destroyed by admitting air into each pleura, the arteries are found as turgid as the veins;[m] but the same results have not been obtained by others;[n] and I presume that the obstruction in the lungs from the want of chemical changes, gradually

[g] Hunter, *On the Blood*, p. 75. sq. Haller had prievously ascertained the same thing, and while allowing the influence of a vacuum, urged it as a proof, that the vacuum was not efficient, but only auxiliary. *El. Physiol.* t. ii. p. 325.

[h] Mr. Spry, *Lancet.* Jan. 1827.

[i] Dr. David Williams, *Edinb. Med. & Surgical Journal,* 1823, p. 528.

[k] *Journal de Physiol.* t. i. p. 111.

[l] *Statical Essays,* vol. ii. p. 6.

[m] *Med. Chir. Trans.* vol. xi.

[n] Dr. Fennel, *The Philadelphia Journal,* Nov. 1822.

lessening the supply to the arteries and producing accumulation in the veins, together with the superior contractile powers the of arteries, are, jointly, quite sufficient to explain the circumstance. The effect of the obstruction in the lungs while the left ventricle continued to propel blood, was strikingly shown by Bichat, who produced enormous congestion of the lungs, liver, spleen, &c., by strangling animals slowly, and found much less if respiration was completely arrested at once, so that the left ventricle ceased to propel blood very soon after the obstruction in the lungs took place.[o] The greater the space into which the former blood can flow from the arteries, the less blood will they contain. Hence, if a ligature is passed round the cavæ, some quantity of blood is found in the arteries; if around the pulmonary artery, less; and when the lungs have been kept distended after death by artificial inflation, after opening the chest, so that all their vessels might be unfolded, the arteries have been found quite empty, though there was no thoracic vacuum,[p] and though the effect of the left ventricle of the heart was destroyed by a ligature on the aorta.

Hence, if Dr. Carson's experiments on this point are accurate, I should ascribe the turgidity of the arteries when the pleuræ were filled with air, and the lungs compressed, to the diminution; and when this was not done, the emptiness of the arteries, to the largeness, of the pulmonary space into which the blood could pass.

The influence of suction has been thought by Dr. Carson to assist in explaining venous absorption.[q]

Dr. Carson ascribes the effects experienced in elevated situations to the rarity of the atmosphere, by which it cannot compress the blood sufficiently to aid the return of this fluid towards the heart. Saussure[r] says, that when he was on the summit of the Alps he experienced extreme fatigue and loss of muscular power, and irresistible, rapid, and violent palpitation, and difficulty of breathing, all which soon ceased on his assuming the horizontal posture, in which, of course, the blood circulates more easily. His guide, a slim old man, was unaffected, and climbed with ease like a goat; and many unaccustomed to such elevations have been equally unaffected, for habit and a strong heart will render the influence of pressure but little necessary.

[o] *Recherches Physiologiques*, p. 225. sq.

[p] Mr. Robert Hunter. *Edinburgh Journal*. Oct. 1824.

[q] l. c. p. 167.

[r] *Voyage dans les Alpes*.

Gravity has been thought by Dr. Carson, as well as by older writers, materially to aid the circulation : — " by the stroke of the heart, a quantity of fluid is withdrawn from one end of the column, and by the synchronous vibration of the arteries an equal quantity is added to the other." " A perpetually repeated generation of motion must be produced through the different parts of the venous system by gravity, and this motion must be from the ends of the veins to the trunks."[s] " The simplest weight of a column of blood in any descending artery is sufficient to raise the blood through open capillaries to an equal height in the corresponding vein, according to the hydrostatical law, that fluids attain the same level in all communicating vessels."[t] Yet, in the horizontal posture, there can be no assistance from gravity, but the circulation proceeds perfectly well; and, indeed, gravity, on the whole, seems to impede the circulation, for if the arms hang down for a length of time, or the legs are not rested horizontally, they ultimately swell. Nothing assists the heart more than a horizontal posture, as seen in syncope, in which the restoring effects are perfectly explicable by its mechanical aid to the heart, without reference to the brain.[u] The effects of posture are necessarily greater in tall persons. In the horizontal posture, the heart having less to do, beats more slowly, and in very tall persons the pulse has been found 12 or 20 beats quicker in the upright posture.

The operation of exercise is very material. If an extremity is not exercised, its circulation always becomes languid, it resists external temperature with difficulty, and wastes, and, if gravity also co-operates by a vertical position, it swells ; and exercise will prevent the congestive agency of a continued vertical position. Violent exercise causes proportionate violence of circulation. The action of muscles evidently operates by compression, and chiefly of the veins, as the coats of the arteries are so much stronger. The blood can go but one way. The stream behind, and the valves in the veins of the extremities, determine the effects of the pressure to be in the course of the circulation. The compressed vessels are at once nearly emptied, and the instant that the pressure is alternately removed are again filled ; and the momentary

[s] l. c. p. 138. sq.

[t] *Elements of Physics.* By N. Arnott, M.D. Lond. 1827. p. 500.

[u] See Bichat, l. c. p. 198. sqq.

impediment during the compression is immaterial, on account of the innumerable venous anastomoses. The progress of the blood cannot but be accelerated. The dyspnœa that is felt arises from the force with which the blood drives through the lungs, and which renders frequent respiration necessary.

In the fœtus the case is analogous, although Dr. Carson has imagined it different, and thought it necessary to frame a little hypothesis to reconcile circumstances. The fœtal lungs, experiencing no atmospheric pressure, are contracted to the utmost, and the diaphragm, suffering no stimulus from the will on account of uneasy sensation arising from want of breath, is completely relaxed, and forced upwards to remove the vacuum; and the venous blood without the thorax must be drawn forcibly into the right auricle, preventing the vacuum which the discharges of blood from the left ventricle tend to produce. In the fœtus, moreover, the blood is propelled into the aorta by *both* ventricles, as Mr. John Bell remarks, and, therefore, the circulation less requires other assistance. The vacuum from the dilatation of the cavities of the heart occurs in the fœtus and all animals which have a heart: but in those which have no such respiration as the human, there can be no assistance to the circulation by *thoracic* vacuum.

The ordinary cause of the first inspiration appears to be the novel impression of cool air upon the surface; for if at any time we are suddenly exposed to a cold wind, or plunge into cold water, the diaphragm and intercostal muscles instantly contract, and a sudden *inspiration* takes place. The blood rushes into the expanded lungs, and, being afterwards obstructed when the inspiratory muscles cease to act and the elastic lungs shrink, gives rise to an uneasy sensation, which is instinctively removed by another inspiration, and thus respiration afterwards continues through life. The fact of respiration commencing before the chord is tied, shows that neither congestion in the aorta, nor deficiency of chemical changes, is the cause of the first inspiration. If an animal is born under warm water, its respiration begins at the moment you choose to bring it up into the air. Buffon proved this by causing a bitch's accouchment to take place in a tub of warm water, and allowing the pups to remain there for half an hour.

The power of excitement of the surface to cause inspiration has been recently shown by Beclard and others, who, on mechanically irritating fœtal kittens still enclosed in the membranes, found inspiratory efforts take place at each irritation.

(B) After much uncertainty, it was thought ascertained by the experiments of Messrs. Allen and Pepys that no oxygen is absorbed in ordinary respiration, but that what disappears goes entirely to unite with the carbon of the blood and produce carbonic acid, the latter being exactly equal in bulk to the oxygen which disappears,—about 27½ cubic inches per minute, or 39,534 in twenty-four hours, according to the experiments of these gentlemen, — a quantity containing about 11 oz. troy of solid carbon, and, perhaps, about double the average result of most other experiments.

But Dr. Edwards has since shown that, however correct were these results, it was erroneous to generalise from them; that more *oxygen* is continually consumed by brutes than goes to the formation of carbonic acid; and that this excess varies from above ⅓ of the volume of the latter to almost nothing.[u] The variation depends not only upon the species, but upon the developement relative to the age, and upon individual differences in adults.

He therefore finds that the bulk of the air is not unaffected by respiration, but that generally a diminution takes place. Dr. Le Gallois[x] and Dr. Delaroche[y] also found that oxygen disappeared in greater quantity than carbonic acid was formed.

Allen and Pepys observed, that if the same air was breathed repeatedly, some oxygen was absorbed and some azote discharged, and that if nearly pure oxygen was employed in the case of guinea-pigs, carbonic acid was produced and a portion of the oxygen replaced by azote, this portion decreasing, however, as the experiment proceeded.

Dr. Edwards ascertained that respiration causes sometimes an increase of *azote*, sometimes a diminution, and sometimes no important difference in its quantity. He thinks that it is always being absorbed and discharged, and that the proportion of these processes differs under different circumstances. Its discharge exceeds at all times in very young animals, as guinea-pigs; and in spring and summer; while its absorption exceeds in autumn and winter, as far as his experiments upon adult sparrows and yellow-hammers go; though occasional exceptions occurred from unappreciated circumstances, powerful enough to overbalance the effect of season.[z] The differ-

[u] *De l'Influence des Agens Physiques sur la Vie.* Paris, 1824. p.410. sqq.

[x] *Annales de Chimie et Physique*, t. iv. p. 115. sq.

[y] *Journal de Physique*, t. 77.

[z] l. c. p. 420. sqq. 461. sqq.

ence in the proportion of the inspired and expired azote never equalled the greatest differences observed between the oxygen which disappeared and the carbonic acid formed. Cold-blooded quadrupeds were shown by Spallanzani[a] to absorb azote, and fish by Humboldt and Provençal.[b] Sir Humphrey Davy had already ascertained the absorption of azote in his own person.

Dr. Edwards's reasons for believing azote to be constantly both absorbed and discharged are: —

1. That if an animal is made to breathe oxygen mixed with $\frac{1}{20}$ of azote, azote is discharged in abundance, as was found by Allen and Pepys, so that when there is little or no azote to be absorbed, its exhalation at once shows itself: and we may conclude that in common respiration its exhalation may be as great, but not observable because nearly an equal quantity is absorbed:

2. When a mixture of oxygen and hydrogen was employed by those chemists, and pure hydrogen by Dr. Edwards, not only was a large quantity (much exceeding the bulk of the animal) given out, but a considerable quantity of *hydrogen* was absorbed,—in Dr. Edwards's experiment equal to the azote given out,[c] proving that exhalation and absorption can proceed together: and he asks why, if hydrogen is absorbed, not much more so azote, which is more fit for respiration and the support of life; and concludes that its absorption may be as great in common respiration, but not observable because a nearly equal quantity is discharged.[d]

Carbonic acid itself is shown by Spallanzani and Dr. Edwards[e] to be exhaled from the lungs independently of the operation of oxygen; — when snails, frogs, fish, or very young kittens are immersed in hydrogen.

Mr. Ellis[f] contends that the carbon is excreted by the pulmonary vessels, and unites with the oxygen externally, and Dr. Prout thinks this opinion corroborated by the fact,[g]—that,

[a] *Mémoires sur la Respiration*, p. 184. 258.

[b] *Mémoires d'Arcueil*, t. ii.

[c] l. c. p. 462.

[d] l. c. 429. sqq.

[e] l.c. p.437. sqq.

[f] *An Enquiry into the Changes induced in Atmospheric Air.* 1807. *Further Enquiries*, &c. 1816.

[g] Dr. Orfila, *Toxicologie Générale*, t.i. p.531. sq. Dr. Magendie had previously found the same result in injecting the solution into the pleura. *Mémoire sur la Transpiration*, p. 19.

when phosphorus dissolved in oil is injected into the blood-vessels, vapours of phosphorous acid stream from the mouth and nostrils,—what would hardly have occurred if the acid had been formed in the vessels, as it would probably have remained in solution in the blood, not being volatile. The phosphorus was probably excreted from the vessels in minute subdivision, and united with the oxygen of the atmosphere upon coming in contact with it, producing phosphorous acid; and the same may be imagined respecting the carbonic.[h]

There can be no reason to adopt this hypothesis on account of the supposed difficulty of the air and blood acting upon each other through the vessels, because we saw in Sect. II. note (G), that they do so, through moistened bladder, out of the body. The well-known secretion and absorption of air by membranes, shown by the existence of air in the air-bladder of fish, the sudden formation of air in the alimentary canal in disease, the separation of carbonic acid gas and of azote in the lungs, the absorption of azote and oxygen in the experiments of Dr. Edwards, the absorption of air in emphysema, and the occurrence of emphysema without injury of the lungs,[i] together with the evolution of carbonic acid gas from the blood under the air-pump or when hydrogen only is breathed,[k]—all show the possibility of oxygen being absorbed by the blood, and carbonic acid given out from it in the lungs, ordinarily, in respiration, as a secretion. Dr. Edwards contends that, since so much carbonic acid is given out from the blood in the respiration of pure hydrogen; and that, since the quantity given out in hydrogen is as great as is observed in common air, there can be no reason to doubt that, in common air, the carbonic acid proceeds from the same source as in hydrogen, *viz.*—is exhaled; more especially as carbonic acid exists largely in the blood: and that the oxygen, therefore, must be absorbed by the blood. But whether mere carbon leaves the blood and forms carbonic acid with the oxygen externally to the vessels, or the oxygen unites with, and the carbonic acid separates from, the blood, much of the affair would appear chemical,—neither all the carbon nor all the carbonic acid gas to be *secreted;* because when venous blood is exposed to oxygen out of the body

[h] Dr. Thomson's *Annals of Philosophy*. 1819.

[i] See a case related by Dr. Baillie, in the *Transactions of a Society for the Improvement of Medical and Chemical Knowledge*, vol. i.

[k] Edwards, l. c. p. 437. sqq.

it becomes florid, and oxygen disappears and is replaced by carbonic acid.

With respect to the change of arterial to venous blood, although exposure to hydrogen or carbonic acid — positive substances, will effect it, and the fact of the separation of carbon occurring when the florid colour is acquired looks as though the presence of carbon were the cause of the dark hue; yet arterial blood, inclosed in vials or in vacuo, grows purple,[l] — a proof that the mere action of the constituents of the blood upon each other is a sufficient cause. And the circumstance of venous blood remaining dark, though by the air-pump carbonic acid is evolved from it, looks rather as if the florid colour were dependent on the operation of oxygen.

The generality of respiration or something analogous among living beings,[m] and all the circumstances attending its performance, induce Dr. Prout to believe that it does something more than effect chemical changes.[n] He considers galvanism as an instrument extensively used by the vital principle, and since galvanic operations probably occur in the action of the constituents of the blood on each other, especially when oxygen is present; and the combination of carbon with oxygen resembles the union of the more oxidisable metal and oxygen in the galvanic

[l] If extravasated, or inclosed between two ligatures in an artery, the same happens. Hunter, *On the Blood*, p. 65. sq.

[m] *Fish* and *crustacea* purify their blood by the air contained in the water which they draw over their gills. They perish if the water is deprived of air: and in this case, as well as when the water is aërated but limited in quantity, and whether it is exposed to the air or in close vessels, they perish sooner as the temperature is higher. Dr. Edwards, l.c. P. ii. ch. 2. And the younger and smaller they are, when there is too little air in the water, the more they come to breathe at the surface, and die if prevented. (p. 118.) Fish die in the air by drying and wasting. (p. 126.) The *syren lacertina* and *proteus anguina*, have both gills and lungs: *insects* have no lungs, but openings on the surface of the body leading to air-vessels are distributed in the interior. All the experiments of naturalists made it appear that no animal could live without oxygen, but M. Biot has asserted, that what are called *blaps* and *tenebrions*, remain in as good a vacuum as can be formed for any length of time without apparent inconvenience. Animals found in many parts of the bodies of others, can hardly be thought to have access to gaseous oxygen. VEGETABLES occasion the same change in the air as animals, according to Mr. Ellis. *Further Inquiries into the Changes induced in Atmospheric Air, &c.*

[n] Dr. Thomson's *Annals of Philosophy*. 1814.

battery, — a great additional purpose of respiration is, in his opinion, to supply or excite galvanism.

Dr. Crawford observed that less carbonic acid was formed in proportion to the height of the temperature;[o] Dr. Jurine, that more was produced when the circulation was quickened, — during the hot stage of fever, digestion, or exercise, and less in the cold stage;[p] and his results were confirmed by Lavoisier and Seguin.[q] Dr. Edwards has found less formed in summer than in winter.[r]

Dr. Prout and Dr. Fyfe[s] have found the quantity of carbonic acid gas diminished by mercury, nitric acid, vegetable diet, tea, substances containing alcohol, depressing passions, long fasting, and fatigue, and probably by sleep. Dr. Prout found that it undergoes in himself an increase from day-break till noon, and a decrease from noon till sun-set, remaining at the minimum till day-break. In the experiments of Allen and Pepys, the formation of carbonic acid gas slackened when their guinea-pigs fell asleep. Dr. Prout also observed that an increase or decrease from the maximum or minimum was followed by a proportional decrease or increase during a diurnal period. It would appear, also, that less is formed in infancy, and more as the adult age is approached, in brutes.[t]

The average number of respirations in a minute in adults is probably twenty, but the absolute number, and the number relative to the pulse, vary both in different individuals, and in the same under different circumstances.

The common quantity of air taken in at each inspiration is about 16.5 cubic inches, and the quantity remaining after death in the lungs of a stout adult man, about 100 cubic inches, accord-

[o] *On Animal Heat*, p. 387.

[p] *Encyclopédie Méthodique*, t. i. p. 494. Dr. Prout also observed this effect of exercise before fatigue occurred.

[q] *Mémoires de l'Academie des Sciences*. 1789. p. 575.

[r] l. c. p. 200. sqq.

[s] l. c. *Dissert. Inaugur. &c.* Edin. 1814. The smallest quantity yet observed was in a diabetic patient of mine, taking very large doses of opium and nux vomica. *Numerous Cases, illustrative of the Efficacy of the Hydrocyanic or Prussic Acid in Affections of the Stomach, with a Report upon its Powers in Pectoral and other Diseases, in which it has been already recommended, and some Facts respecting the Necessity of varying the Doses of Medicines according to circumstances, and the Use of Opium in Diabetes.* By John Elliotson, M.D. &c. p. 99.

[t] Boyle, *Works*, vol. iii. p. 360. Edwards, l. c. p. 189. sqq.

ing to Allen and Pepys. Dr. Bostock, agreeing with Dr. Menzies and many others, believes 40 cubic inches to be the average inspiration, and thinks that 160 or 170 remain in the lungs after ordinary expiration,[u] for these organs are never emptied by expiration.

The ordinary quantity of aqueous vapour emitted by the lungs, trachea, throat, and mouth, may be about 20 oz. in 24 hours.[x]

Camphor, phosphorus, ether, diluted alcohol, gases, and various odorous substances, when introduced into the system, escape in a great measure by the lungs: whence they are perceived in the breath. Dr. G. Breschet and Dr. Milne Edwards, conceiving that in the dilatation of the lungs by inspiration, the enlarged space would cause not only the air to rush in, but the exhalation from the surface of the air-cells and pleura to increase and exceed that from other parts, have made several experiments which prove this to be the case. On injecting a *small* quantity of oil of turpentine into the crural vein, the breath instantly smelt strongly of it, and the pleura on being cut open did the same; while no odour of it arose on exposing the peritonæum. If a larger quantity was employed, it impregnated every part. If, instead of natural respiration, artificial was instituted, in which the air does not enter the lungs by the formation of a vacuum on the expansion of the chest, but is forced into them and itself expands the chest, no more exhalation of odorous substances took place from the lungs than from other parts; and, indeed, if a cupping-glass was applied over another denuded part, the odorous substance was given out there, while the lungs afforded no sign of it.[y]

(F) When the air is not changed, death in general occurs long before all the oxygen is consumed, through the carbonic acid which is formed; but bees, some worms and mollusca, completely deoxidize it.[z]

Lavoisier removed the carbonic acid by potash as quickly as it was produced, and found that a guinea-pig could live in air containing but 6.66 per cent. of oxygen, and with still less became only drowsy.[a]

[u] *An Elementary System of Physiology*, vol. ii. p. 24. sq. Dr. Thomson thinks the estimate of Menzies most correct. *System of Chemistry*, vol. iv.

[x] See Hales. See also infra, Sect. XI. note (G).

[y] *Recherches Expérimentales sur l'Exhalation Pulmonaire*. Paris, 1826.

[z] Vauquelin, *Annales de Chimie*, t. xii. p. 278. Spallanzani, *Mém. sur la Respiration*, p. 62.

[a] Some assert that the respiration of pure oxygen excites violently, others gently, others not at all; some, that more oxygen is consumed than in common, some

Dr. Edwards advances, contrary to Morozzo,[b] that every warm-blooded animal perishes instantly[c] when placed in the air in which another has died through want of renovation, and that all of the same class among them deoxidize it equally, though in different times. This time will occasionally differ $\frac{1}{3}$, notwithstanding the size of the body and the movements of the chest be equal in them, and the carbonic acid be removed as quickly as formed. The young deoxidize it more slowly than adults; and the young, if quite deprived of air, die later than adults.[d] Indeed, Buffon found, and Dr. Le Gallois and Dr. Edwards have confirmed his discovery, that new-born animals of many species, as dogs and rabbits, will live a long time without air, even after they have been allowed to respire. This period lessens as the animal's temperature rises with age; and in those whose temperature is at birth high, as guinea-pigs, it is very short.[e] They live longer than adults also in a limited quantity of air.[f] Amphibious animals likewise live long without air.[g]

Persons have been said to be able, by habit, to live without air a considerable time. Death generally occurs at the latest in one or two minutes, when respiration is suspended; but by habit some few divers of the swimming school at Paris can remain under water three minutes.[h] If the system is in an extraordinary nervous

no more. Pure hydrogen and azote appear to destroy by the mere exclusion of oxygen; carbonic acid by poisoning, but, if not diluted with rather more than double its bulk of common air, it will not pass the glottis. Nitrous oxide intoxicates quickly, briefly, and without consequent exhaustion, and appears to be absorbed by the blood. (See Sir Humphry Davy's *Researches*, &c.) Drowning destroys life only by the exclusion of air, and as the glottis closes, little or no water, — nothing often but frothy mucus, is found in the air-passages. Yet Professor Meyer asserts, that he has seen the fluid in which the animal was drowned, generally, in the lungs, in his experiments.

[b] *Journal de Physique*, t. xxv. p. 102. sqq. The usual reason that an animal will live in air in which another has died, is, that it comes fresh and strong into it, and therefore resists the poison better than its enfeebled predecessor.

[c] *Mémoires de l'Academie des Sciences*. 1789. p. 573.

[d] l. c. p. 184. sqq.

[e] Edwards, l. c. p. 191. sqq.

[f] l. c. p. 513. sqq.

[g] Sir Anth. Carlisle, *Phil. Trans.* 1805.

[h] Edwards, l. c. p. 269. Mr. Brydone (*Tour through Sicily and Malta*), frequently saw divers remain, in the Bay of Naples, under water, for three minutes. In Percival's *History of Ceylon*, they are said sometimes to remain five minutes under water.

Some very grand instances of the exaggeration on this subject, will be found in an amusing and useful book, entitled *The Uncertainty of the Signs of Death.*

state of insensibility, the absence of air, like the absence of food or the administration of strong agents, may be borne for a very long time. Even fainting renders submersion less dangerous.

Whether venous blood differs from arterial in containing more carbon or less oxygen, it is not calculated for life. When injected into the carotids, the brain becomes affected, as if poisoned, and death gradually ensues; and when it circulates through the coronary arteries of the heart,—the action of which organ will continue though its left cavities are supplied with venous blood,—the heart's motion ceases, and the functions of each organ are impeded and at length cease if venous blood circulates through its arteries.[1] When death occurs by impediment to the functions of the lungs, the heart loses its irritability by its substance becoming penetrated with venous blood and ceases to propel the blood of its cavities; and the brain, becoming powerless from the same cause, ceases both to perceive uneasiness in the lungs from the want of fresh air and to be able to will inspiration. If the death of the body arise from the brain, it is by the brain being unable to continue respiration.

Some suppose that respiration is very instrumental in preventing the putrefaction of the living body; and this by carrying off its carbon, — the substance which, in the spontaneous decomposition of animals, is the first rejected, and unites with the oxygen

---

M. D'Egly, Member of the Royal Society of Inscriptions, declares that he was engaged to a dinner for which the fish was to be provided by a Swiss diver, who got his living by plunging into the water and pulling the fish out of their holes. The dinner hour arrived, but no fish. Drags were employed, and the diver's body found. The curate wished to bury it immediately, as it had been nine hours under water, but M. D'Egly determined on attempting resuscitation, and succeeded in three quarters of an hour. The Rev. Mr. Derham, in his *Physico-Theology*, is more credulous than the Curé; he quotes Pechlin for the case of a man pensioned by the queen for having joined this world again, after remaining upright under water, his feet sticking in the muddy bottom, for sixteen hours, at Tronningholm. Yet this is nothing; for Mr. Tilesius, the keeper of the royal library, has written an account of a woman whom he saw alive and well, after being three days under water. And this is nothing; for Mr. Burmann declares he heard a funeral sermon at Boness in Lithovia, upon an old man of seventy, who, the preacher protested, had fallen into the water when sixteen years old, and remained under it for seven weeks. Mr. Brydone was told that one diver, called Calas, but nicknamed Pesce, could live several days in the sea; and Kircher asserts, that this aquatic person could walk under water from Sicily to Italy.

[1] Bichat, *Recherches Physiologiques*, p.ii. art. 6, 7, 8.

of the atmosphere; and indeed Spallanzani found, that the dead bodies of animals deoxydated the air after death, and often as much as during life, before decomposition was perceptible.[k] He says also, that torpid animals, whose respiration had entirely ceased, also carbonated it. As the latter fact cannot be ascribed to the separation of carbon to the lungs, nor to the mere chemical changes of decomposition, it probably arises from the functions of the skin.

From the chyle entering the venous blood about to arrive at the lungs, respiration has been thought to assist in assimilation. More carbonic acid, however, is not found after every meal, nor less during fasting, till it proceeds to the length of debility. Many animals sleep after feeding; yet in sleep less is produced.

(G) The experiment consisted in laying the lungs completely bare, and reviving the animal by artificial respiration. Hooke varied it by pricking the surface of the lungs and forcing a continued stream of air through them.

The following are the words of Harvey: "It would appear that the use of expiration is to purify and ventilate the blood, by separating from it these noxious and fuliginous vapours."

[k] *Mém. sur la Respiration.* See Dr. Bostock, l. c. vol. ii. p. 184. sqq.

SECT. IX.

OF THE VOICE AND SPEECH.

152. We have described the chief use of respiration. We shall hereafter mention how far it contributes to the conversion of the chyle into blood, and to the support of almost the whole class of natural functions. Its other uses are at present to be considered.

And first, respecting the *voice.*[a] This begins after birth, and proceeds from the lungs, as was observed long ago by Aristotle, who called those animals only vocal, which breathed by means of lungs. The voice is, properly speaking, a sound, formed, by means of expiration, in the *larynx*, which is a most beautifully constructed organ, fixed upon the top of the windpipe, like a capital upon a pillar.[b]

153. The larynx is composed of various cartilages, which, being united together in the form, as it were, of a little box,[c] and supplied with a considerable and wonderful apparatus of muscles,[d] may be moved altogether, or separately, according to the variations of the voice.

154. The part of the larynx most concerned in producing the voice, is the *glottis*, or narrow opening of the windpipe, having the epiglottis suspended, and, in a manner, fixed upon it. It is clearly ascertained, that the air, expired from the lungs, and striking properly upon the margins of the glottis, becomes sonorous.

[a] Th. Young, *Philos. Trans.* P. i. 1800.

[b] Jan. Marg. Busch, *De Mechanismo organi Vocis hujusque functione.* Groning. 1770. 4to.

[c] Soemmerring, *Icones organorum Gustus et Vocis.* Francof. 1808. fol.

[d] B. S. Albinus, *Tab. Muscul.* Tab. X. fig. 1—15. Tab. XI. fig. 45—48. Tab. XII. fig. 1—7.

155. But it has been disputed what changes the glottis undergoes in modulating the voice: whether it is alternately widened and contracted, as Galen and Dodart supposed, or whether, according to Ferrein, the variations of voice are effected rather by the tension and relaxation of its ligaments.

The latter, consistently with his opinion, compared the larynx to a violin; the former, more consistently with nature, to a flute.[e]

Every thing considered, we must conclude that the glottis, when sounding, experiences both kinds of changes; since the grave and acute modulation of the voice must depend very much upon the alterations produced in the glottis by the ligaments, especially the *inferior* thyreo-arytenoids — the *vocal chords* of Ferrein, and by the corresponding modification of the *sinuses* or *ventricles of the larynx*.[f] (A)

156. That every degree of motion in the glottis is directed by the numerous muscles of the larynx, is proved by the beautiful experiment of tying or dividing the recurrent nerves, or par vagum,[g] and thus weakening or destroying the voice of animals. (B)

157. Man and singing-birds have the power of *whistling*. In the latter, it is accomplished by a larynx placed at each extremity of the wind-pipe and divided into two portions.

[e] Kratzenstein viewed the glottis and larynx as *a kind* of drum, with its head bisected. *Tentamen de natura et charactere Sonorum Litterarum Vocalium*. Petrop. 1781. 4to.

I would, in some sense, compare it to an *Æolian harp*, particularly one of the description found by Labillardière in Amboyna. *Voyage à la Recherche de* La Perouse, t. i. p. 326.

[f] See some experiments made at Göttingen with the view of settling this controversy, in J. G. Runge's Dissertation *De Voce ejusque Organis*. L. B. 1753. 4to.

Also consult Jos. Ballanti, *Commentar. Instituti Bonon.* t. vi.

And Vicq.-d'Azyr, *Mém. de l'Acad. des Sc. de Paris.* 1779.

[g] Respecting this celebrated experiment, anciently made by Galen, consult among others W. Courten, *Philos. Trans.* N. 335.

Morgagni, *Ep. Anatom.* xii. No. 20. P. P. Molinelli, *Comment. Institut. Bonon.* t. iii.

J. Haighton, *Memoirs of the Medical Society of London*, t. iii.

The former, though possessing a single and undivided larynx, has learned, I imagine, to imitate birds by the coarctation of his lips.[h] (C)

158. *Singing*, which is compounded of speech and a musical modulation of the voice, I conceive to be peculiar to man and the chief prerogative of his vocal organs. The power of whistling is innate in birds; many of them may easily be taught to pronounce words, and instances have been known of this even in dogs. But it is recorded, that genuine singing has once or twice only, and then indeed but indifferently and with the utmost difficulty, been taught to parrots; while, on the other hand, scarcely a barbarous nation exists, in which singing is not common.[i]

159. *Speech* is a peculiar modification of the voice, adjusted to the formation of the sounds of letters by the expiration of air through the mouth or nostrils, and in a great measure by the assistance of the tongue, applied and struck against the neighbouring parts, the palate and front teeth in particular, and by the diversified action of the lips.[k] (D)

The difference between voice and speech is therefore evident. The former is produced in the larynx; the latter by the peculiar mechanism of the other organs above described.

Voice is common to both brutes and man, even immediately after birth, nor is absent in those unfortunate infants who are born deaf. But speech follows only the culture and employment of reason, and is consequently, like it,

[h] The larynx, even among the most ferocious people, is capable of imitating the sounds of brutes. Consult, v. c. Nic. Witsen, *Noord en Oost — Tartarye*, ed. 2. Amst. 1705. vol. i. p. 165., respecting the inhabitants of New Guinea of the southern hemisphere, called *Papus*. And J. Adair, *History of the American Indians*, p. 309., respecting the Choktah tribe of North America.

[i] I have in my hands the testimony of most respectable travellers, in regard, for instance, to the inhabitants of Ethiopia, Greenland, Canada, California, Kamtschatka, &c., and therefore wonder at the assertion of Rousseau, — that singing is not natural to man. *Dictionn. de Musique*, t. i. p. 170. Geneva, 1781. 12mo.

[k] See Rich. Payne Knight, *Analytical Essay on the Greek Alphabet*. Lond. 1791. 4to. p. 3.

the privilege of man in distinction to the rest of animal nature. For brutes, natural instinct is sufficient: but man, destitute of this and other means of supporting his existence independently, enjoys the prerogative of reason and language; and following, by their means, his social destination, is enabled to form, as it were, and manifest his ideas, and to communicate his wants to others, by the organs of speech.

160. The mechanism[1] of speech and articulation is so intricate and so little understood, that even the division of letters and their distribution into classes[m] are attended with much difficulty.

The division, however, of Ammann,[n] into 1. vowels, 2. semi-vowels, and 3. consonants, is very natural:

I. He divides the vowels[o] into *simple* — *a*, *e*, *i*, *y*, *o*, *u*,

And mixed — *ä*, *ö*, *ü*.

These are formed by the VOICE only.

The semi-vowels and consonants are articulated by the mechanism of SPEECH.

II. The semi-vowels are *nasal* — *m*, *n*, *ng* (*n* before *g*, which is nearly related to it), that is, the labio-nasal *m*, the dente-nasal *n*, and the gutture-nasal *ng*;

Or *oral* (lingual) — *r*, *l*, that is, *r* with a vibration of the tongue, or *l* with the tongue less moved.

III. The consonants he distinguishes into *sibilant* (pro-

[1] Consult F. Mercur. ab Helmont, *Alphabeti vere naturalis Hebraici Delineatio.* Sulzbac. 1657. 12mo.

Joach. Jungius, *Doxoscopiæ Physicæ Minores* (1662.) 4to. Append. Section i. P. ii. fol. Gg. ii. 3.

J. Wallis, *Grammatica Linguæ Anglicanæ, cui præfigitur de loquela s. sonorum omnium loquelarium formatione tract. grammatico-physicus.* Ed. 6. Lond. 1765. 8vo.

Gottl. Conr. Chr. Storr, *De Formatione Loquelæ.* Tubing. 1781. 4to.

[m] K. G. Anton, *über Sprache in Rücksicht auf Geschichte der Menschheit.* Görlitz. 1799. 8vo.

Er. Darwin, *Temple of Nature. Addit. Notes,* p. 112.

[n] His *Surdus Loquens.* Amst. 1692. 8vo. Enlarged under the title of *Dissert. de Loquela.* Ib. 1700.

[o] Respecting their formation, consult Chr. Theoph. Kratzenstein, *Tentamen,* recommended above.

nounced in succession) — *h*, *g*, *ch*, *s*, *sh*, *f*, *v*, *ph*, that is *h*, — formed in the throat, as it were a mere aspiration; *g* and *ch*, — true consonants; *s*, *sh*, — produced between the teeth; *f*, *v*, *ph*, — formed by the application of the lower lip to the upper front teeth:

And *explosive* (which are, as it were, suddenly exploded, by an expiration, for a time suppressed or interrupted), viz. *k*, *q*, — formed in the throat; *d*, *t*, — about the teeth; *p*, *b*, — near the lips;

And *double* (compound) — *x*, *z*. (E)

161. We must just mention certain other modifications of the human voice, of which some, as hiccup and cough, belong more properly to pathology than to physiology, but are very common in the most healthy persons; and others, as crying and laughing, appear peculiar to the human race.

162. Many of these are so closely allied, as frequently to be converted into each other; most also are variously modified.

In *laughter* there is a succession of short, and, as it were, abrupt expirations.[p]

Coughing is a quick, violent, and sonorous expiration, following a deep inspiration.[q]

Snoring is a deep, sonorous, and, as it were, tremulous inspiration, from the vibration of the velum palati during deep sleep with the mouth open.

Sneezing, generally the consequence of an irritation of the mucous membrane of the nostrils, is a violent and almost convulsive expiration, preceded by a short and violent inspiration.[r]

Hiccup, on the contrary, is a sonorous, very short, and almost convulsive, inspiration, excited by an unusual irritation of the cardia.[s]

[p] Fr. Lupichius, *De Risu*. Basil. 1738. 4to.

Traité des Causes physiques et morales du rire. Amst. 1788. 8vo.

[q] J. Melch. Fr. Albrecht, (Præs. Hallero) *Experimenta in vivis animalibus circa tussis organa exploranda instituta*. Gotting. 1751. 4to

[r] Marc. Beat. L. J. Porta, *De Sternutatione*. Basil. 1755. 4to.

[s] C. J. Sig. Thiel, *De Singultu*. Gotting. 1761. 4to.

In *crying* there are deep inspirations, quickly alternating with long and occasionally interrupted expirations.[t]

Sighing is a long and deep inspiration, and the subsequent expiration is sometimes accompanied by *groaning*.[u]

Nearest in relation to sighing is *gaping*,[x] which is produced by a full, slow, and long, inspiration, followed by a similar expiration, the jaws at the same time being drawn asunder, so that the air rushes into the open fauces and the Eustachian tubes. It occurs from the blood passing through the lungs too slowly: *v. c.* when the pressure of the air on the body is diminished, as upon very high mountains. A peculiar feature of gaping is the propensity it excites in others to gape likewise; arising, no doubt, from the recollection of the pleasure it produced. (F)

NOTES.

(A) Numerous explanations have been attempted of the mechanism of the human voice, but these, having been formed at a time when the laws of sonorous bodies were but very imperfectly understood, are all more or less unsatisfactory. The recent investigations of Dr. Savart, have enabled him to explain the construction of the vocal organs from principles which had hitherto escaped the observations of experimentalists. The facts adduced by him prove that the production of the voice is analogous to that of the sound of wind instruments, and that the short column of air contained within the larynx is susceptible, *from the nature of the elastic sides which confine it* and from the manner by which it is excited, of rendering sounds, both of a peculiar nature and much graver than its dimensions would seem to indicate. After establishing the preliminary facts by numerous experiments, he thus accounts for the formation of the voice.

The vocal organ, composed of the larynx and the cavity of the

[t] J. F. Schreiber, *De Fletu.* L. B. 1728. 4to.

[u] Dav. C. Em. Berdot, *De Suspirio.* Basil. 1756. 4to.

[x] Just. Godofr. Günz, (Præside Walthero) *De Oscitatione.* Lips. 1738. 4to.

mouth may be considered a conical tube, in which the air is put in motion in a similar manner as in flute organ-pipes; this tube is so constructed that, notwithstanding its small dimensions, it is capable of rendering a great variety of sounds, some of which are very grave; its inferior part being composed of elastic sides capable of different degrees of tension, whilst the mouth opening more or less, and thus changing the dimensions of the column of air, exercises a considerable influence on the number of its vibrations. By constructing a pyramidal tube of nearly the same length and capacity as the vocal tube, and membranous at its lower part, all the sounds of an ordinary voice can be produced from it, either by varying the tension of the membranes, or by altering the size of its orifice. The trachea is terminated at its upper part by a narrow opening which may be diminished or increased by the approximation or recession of the arytenoids, and by the contraction of the thyreo-arytenoid muscles. This opening performs the same office as the *lumière* (sound-hole) of organ-pipes. But, for the sound thus produced to unite all the known qualities, the tension of the extensible parts of the sides of the vocal tube must be proportionate with that of the sides of the ventricle, as well as that of the superior and inferior ligaments; and the orifices through which the air escapes must be susceptible of varying and of adapting themselves so as to give the best possible result. For these purposes nature has formed these parts of elastic or muscular tissues. The thyreo-arytenoid constitutes itself the inferior and external sides of the ventricles; the uses of this muscle (of which Dr. Savart gives a very accurate description), are the following: when it contracts it gives the proper degree of tension for the sound required, to the lower part and external side of the ventricle, as well as to the edge of the orifice through which the air passes from the trachea; by means of the extremities of its oblique fibres it acts also on the fold of mucous membrane which forms the upper part of the extensible portion of the vocal tube. Its action upon this part is aided by that of a small muscle which should be called the *superior thyreo-arytenoid*, for it extends obliquely from the external and lower part of the arytenoid, upwards and forwards, to the rounded angle of the thyreoid cartilage, to which it is attached by very short tendinous fibres. The office of this muscle is to increase the tension of the external side of the ventricle, conjointly with the oblique fibres of the thyreo-arytenoid, several fibres of which are interwoven with it, and to which it serves as a support. After death, these two muscles being more or less relaxed, the external and internal sides of the ventricles collapse together, and the folds of the mucous membrane are found relaxed. The superior ligaments have no peculiar muscle, and they are sufficiently rigid and thick to dispense with this aid. The two folds of mucous membrane placed at the upper termination of the larynx, and which float in the air which vibrates around them, are susceptible of a variable tension which also influences the sound.[x]

(B) Dr. Le Gallois ascertained that the division of the recurrent nerves frequently proves even fatal to animals. This effect, however, varies with the species and age. The danger diminishes as the animal is older; and, after a certain age, little inconvenience follows, because the (anterior part of the ?) opening of the glottis is larger proportionally to the capacity of the lungs, not merely in some species than in others, but in old than in young animals.[y]

(C) In whistling, the coarctation of the lips only serves as an embouchure to the column of air contained within the mouth and larynx. The varieties of intonation entirely depend on the alterations of the tongue and on the corresponding motions of the larynx. For the higher sounds the tongue is brought forwards and the larynx raised, and for the lower sounds the tongue recedes and the larynx is depressed.

(D) I am indebted to the powerful Dr. Conyers Middleton for the knowledge of two cases of distinct articulation with at least but little tongue.[z] In his exposure of the *pious* deceptions of weak and wicked Christians during the first centuries of the Christian era, he notices a pretty tale of an Arian prince cutting out the tongues of some of the orthodox party and these being as able to talk as before; nay one (*O hominum impudentia!*), who had been dumb from his birth, gained the faculty of speech by losing his tongue. Granting the fact, and even that the tongues were completely extirpated, he refers, for the purpose of proving

[x] *Mémoire sur la Voix Humaine,* par F. Savart. Magendie's *Journal de Physiologie,* t. v. p. 367.

Mémoire sur les Voix des Oiseaux, par F. Savart. *Annales de Chimie.*

[y] *Expériences sur le Principe de la Vie.*

[z] *An Enquiry into the Miraculous Powers, &c.* Miscellaneous Works, vol. i. p. 148. 4to.

there was no miracle in the case, to two relations of similar instances by medical men.[a] Professor Thomson found the speech little impaired after the bullets had carried away more or less of the tongue.[b] Louis, Richter, Huxham, Bartholin, and Tulpius mention similar cases. An instance of good articulation after the loss of the apex and body of the tongue quite down to the os hyoides occurred in this country, and was seen by the Royal Society.[c]

(E) For this note, as well as (C) I am indebted to my excellent friend, Mr. Charles Wheatstone, who has already contributed so much to science as to justify the highest expectations.

The elements of which all the spoken languages of mankind are composed, consist of the modifications given sometimes to the breath, and at other times to the voice, during their passage through the cavity of the mouth; these modifications are principally effected by the altered positions of the lips and tongue with respect to the fixed parts of the containing cavity.

The classification of these articulations into vowels and consonants has been generally recognised.

The *vowels* are formed by the voice, modified, but not interrupted, by the varied positions of the tongue and lips. Their differences depend on the various proportions between the aperture of the lips and the internal cavity of the mouth, alterable by the different elevations of the tongue. The vowel *aw* (as pronounced long in *a*ll, and short in g*o*t) is formed by augmenting the internal cavity by the greatest possible depression of the dorsum of the tongue, and, at the same time, enlarging the separation of the lips. Departing from this sound there are two series: 1st. In which the external aperture remains open, and the internal cavity gradually diminishes by the successive alterations of the tongue. 2d. In which the positions of the tongue are successively the same as in the first series, but the aperture of the lips is diminished. The approximation of the lips produces

[a] Jussieu, *On Speech without a Tongue. Mém. de l'Acad. des Sciences.* 1718. p. 6.

[b] *Report of Observations made in the British Hospitals in Belgium, after the Battle of Waterloo; with some Remarks on Amputation.*

[c] *Account of a Woman who spoke fluently without a Vestige of Tongue. Phil. Trans.* 1742. p. 143.

Dr. Parson's *Account of Margaret Cutling, who had lost her Tongue. Phil. Trans.* 1747. p. 621.

a more sensible effect as the inner cavity is more enlarged; hence two modifications of the first sounds of the second series are easily recognised, whilst only one variety of the others is readily appreciable, as will be shown in the following table.[d] Each of these vowels may be long or short, according to the duration of its sound in a syllable.

TABLE OF VOWELS.

Each series formed by the gradual elevation of the tongue.

First Series. — The lips fully open.			Second Series. — The lips partially open.			Third Series. — The lips nearly closed.		
	As pronounced			As pronounced			As pronounced	
	Long, in	Short, in		Long, in	Short		Long, in	Short, in
1. *aw*	*caught*, *fall*	*folly*	6. *o*	*coat*	Not used.	11. *oo*	*cool*	*full*
2. *ah*	*father*, *car*	*dull*	7. *o*	*court*				
3. *ae*	*nae* (Scotch)	*man*	8. *eu*	bonh*eur* (Fr.)				
4. *a*	*fair* [e]	*met*	9. *eu*	affr*eux* (Fr.)				
5. *e*	*feet*, *the*	*fit*	10.	Expressed in German by *ü*, in Danish and Swedish by *i*, in Dutch and French by *u*.				

The above table exhibits all the most usually pronounced vowel sounds, but practised ears might distinguish others intermediate in each series. When these vowels are sounded, the soft palate is raised so as to prevent the voice from issuing through the nasal channels; when, on the contrary, the soft palate is depressed, the partial escape of the breath through the nostrils modifies all the preceding sounds in a very evident manner. To distinguish these two modes of articulating the vowel sounds, we may adopt Dr. Darwin's terms, orisonant and narisonant vowels.

Consonants may be divided into continuous (sometimes called liquids or semi-vowels,) and explosive. For the latter, the breath or voice is stopped in its passage through the mouth; for the former, it is allowed a free passage, though the apertures are more narrowed than for the vowels.

[d] For the more open sounds, the jaws are generally more separated; but this is not indispensable.

[e] This vowel is much used by the Irish in pronouncing such syllables as *bate*, *fait*, &c., for our English words beat, faith, &c.

But the most comprehensive and important division of these articulations is into aspirates and sonants; meaning by the former term, the modifications of the breath, and by the latter, those of the voice. In ordinary speaking these are mingled together to form the elementary syllables of language. The aspirates, or sounds indicated by the characters *p*, *f*, *sh*, *s*, *th* (in *th*ing), *t*, *k*, *ll*, (Welsh), differ from the sonants, or those represented by *b*, *v*, *z* (in azure), *z* (in puzzle), *th*, (in *th*e), *d*, *g* (in gay), *l*, only by the latter being accompanied with the vocal sound.

Every sonant has its corresponding aspirate, though many of the latter are unknown to the English language, such are the aspirates corresponding to the sonants *r*, *m*, *n*, *ng* (in so*ng*), &c.

When forming the component parts of syllables, the aspirates, as well as the sonants, are always articulated with sonant vowels. An aspirate vowel, followed by its vocal enunciation, is always represented by the character *h*, but it is never pronounced separately, except in whispering.

The consonants, like the vowels, are divided into orisonant and narisonant. The only narisonant consonants in our language, are those corresponding to the orisonant explosives *b*, *d*, and *g* (in gay), — viz. *m*, *n*, and *ng* (in so*ng*). By this mode of pronunciation the sounds are rendered continuous.

TABLE OF CONSONANTS.

Continuous.			Explosive.			
	Aspirate.	Sonants.		Aspirates.	Orisonants.	Narisonants.
1.	*f*	*v*	10.	*p*	*b*	*m*
2.	—	*y*	11.	*t*	*d*	*n*
3.	*sh*	*z* & *j* in a*z*ure.	12.	*k*	*g* in *g*old.	*ng* in so*ng*.
4.	*s*	*z* in *z*any.				
5.	*th* in *th*ink	*th* in *the*				
6.	(not used)	*r*				
7.	*ll*	*l*				
8.	—	*l* in fi*ll*e (Fr.)				
9.	*ch* in lo*ch* (Scotch) na*ch* (Ger.)	*g* in sa*g*en (German) *g*emis (Sp.)				

This table shows that for all the consonants employed in the English language, only ten positions of the mouth are required, the modifications being effected by other means. Among the modifications not already described, may be particularised the reduplication of the 10th, 11th, and 12th sounds; the first occasioned by the vibratory motion of the lips, the others by that of the tongue.

Observations: — 1. The lower lip presses on the upper teeth, but allows the air to escape between them; a similar sound is produced by allowing the breath to pass through the lips when nearly closed: — 2, 3, 4, 5. These sounds may be considered as the continuation of the first series of vowel sounds; for placing the mouth in the position for *e* (5.), and continuing to elevate the back part of the tongue, and, at the same time, to curl its tip, these sounds will be successively produced: — 6, 7, 8. These sounds differ from the preceding four, inasmuch that the *back part* of the tongue does not approximate to the palate; the mouth being placed for the second vowel, the front of the tongue is elevated so as to touch the palate just above the teeth; for the *r*, the point is drawn back, so as to allow the air to escape; and for the *l*, the point is firmly pressed against the palate, and the breath escapes by the two sides:—for the *l*, (in fi*ll*e), the air escapes with more difficulty: — 9. These are used in the Gaelic and German, but not in English: — 10, 11, 12. These sounds are produced by the forcible escape of the breath, or voice, after a complete obstruction by the lips or tongue. The obstruction by the lips gives *p*, or *b*; that by the front of the tongue above the upper teeth, *t*, or *d*; and that by the back of the tongue against the palate, *k*, or *g*; these different articulations may therefore be distinguished as Labial, Dental, and Palatal. When the sound escapes through the nostrils it becomes continuous; the *m*, *n*, and *ng* are therefore not explosives.

The alphabetic characters invented as visual and permanent representations of the articulations of speech, are very inadequate to effect the purpose intended. In the English language there are but five characters to indicate all the varieties of the vowels, viz. *a*, *e*, *i*, *o*, *u*; of these, one only is pronounced when uncombined, as a pure vowel; this is *e*,—the 5th sound in the table of vowels; the other four are diphthongs or combinations of two vowels; *a* is the 4th and 5th; *i* is the 3d and 5th; *o* is the 6th and 11th; and *u* is the 5th and 11th. When constituting parts of syllables, the same character represents many different vowel sounds.

The consonantal characters are not quite so arbitrary, though among these there are some simple sounds expressed by two letters, and others which have no character to denote them; and on the other hand there are several redundant letters representing two simple sounds. *f*, *v*, *r*, *l*, *p*, *t*, *k*, *b*, *d*, *m*, and *n*, are generally constant in their signification. The simple sounds represented by two characters are *sh*, *th* (in *th*ink), *th* (in *th*e), and *ng* (in so*ng*). The single characters representing more than one sound are *s* (in *s*ea, hi*s*, *s*ure, and vi*s*ion); *z* (in *z*any and a*z*ure), *g* (in *g*ay and *G*eorge). The redundant letters are, *c* (having the sound either of *s* or *k*), *q* (*k* followed by the eleventh vowel); *j* (compounded of *d* and the second pronunciation of the *z*, and the same as the *g* in *G*eorge), and *x* (standing for *ks*, or *z*). *y*, as generally pronounced, and *w*, are not consonants; the first represents the 5th, and the second the 11th vowel of the table, when immediately succeeded by another vowel.

The consonants will be best compared by articulating them all, uniformly preceded or followed by the same vowel; as *fe*, *she*, *se*, *the*, *pe*, *te*, *ke*, &c. or *ef*, *esh*, *es*, *eth*, *ep*, *et*, *ek*, &c.

It is by no means improbable that the progress of modern art may present us at some future time with mechanical substitutes for orators and preachers. For, putting aside the magic heads of Albert the Great and Roger Bacon, Kratzenstein actually constructed an instrument to produce the vowels,[f] and De Kempelin has published a full account of his celebrated speaking machine which perfectly imitated the human voice.[g] The celebrated French mechanician, the Abbé Mical, also made two heads of brass which pronounced very distinctly entire phrases; these heads were colossal, and their voices were powerful and sonorous. The French government refusing, it is said, in 1782, to purchase these automata, the unfortunate and too sensitive inventor, in a paroxysm of despair, destroyed these master-pieces of scientific ingenuity.

Having fully explained the various articulations used in oral

[f] *Observations sur la Physique*, par Rosier, Supplement, 1782. p. 758.

[g] *Ueber den Mechanismus der Menschlichen Sprache.* Vienna, 1791.

language, it now only remains to investigate the difference between the inflexions of the voice in singing and in speaking.

The various muscular adaptations of the larynx renders it capable of producing every inflexion of musical tone within a certain compass, seldom exceeding that of two octaves. In *singing*, sounds, each constant in its degree of tune, follow each other according to the rules of melody: whilst in *speaking*, the voice slides up and down, and "does not dwell distinctly, for any perceptible space of time, on any certain level or uniform tone, except the last tone on which the speaker ends or makes a pause." Provincial dialects, and even individual modes of speaking, differ much in the extent and nature of these slides. Steele has endeavoured to establish a system of notation for these inflexions, and other modifications of the voice necessary to be observed by the orator, and has by this means proposed to perpetuate the most splendid specimens of histrionic, forensic, and senatorial eloquence. [h] To proceed farther with this subject would be an infringement on the province of philology.

(F) I know no reason to believe that the tendency to *gaping* on seeing others do so, arises from the recollection of the pleasure it affords; or that *hiccup* is produced by an irritation of the cardia more than of any other part of the stomach. Gaping occurs chiefly during fatigue or hunger; when we are but half awake, either before or after sleep; and in ague and hysteria. In hiccup, I think, that, after the inspiration has proceeded a certain length, the glottis closes, and the diaphragm endeavours in vain to contract farther.

In *laughter*, there is more or less noise at each little expiration, from a mere sort of rustling sound to loud peals; the mouth is more or less lengthened, and its angles drawn up, and in extreme laughter it is opened still more by the descent of the lower jaw; if hearty, the tears run over, the head shakes, and even the body, and respiration is interrupted, and actual pain of the sides and diaphragm is felt. Some of our comedians have absolutely agonized me. It arises from drollery, the anticipation of gratification, or actual gratification, or tickling; it is also common in hysteria.

In *coughing*, the mouth opens that the air may rush in that

[h] *Prosodia Rationalis; or, An Essay towards establishing the Melody and Measure of Speech, to be expressed and perpetuated by peculiar Symbols.* 2d edit. London, 1779.

direction, since the current is not required in the nostrils as in sneezing, and these would not afford sufficient vent. The glottis lessens just before the expiration.

In *sneezing*, the opening of the fauces is lessened, and the head bent back, that the current may be directly through the nostrils, in which the irritation generally exists.

Haller is well worth reading on these subjects.[i]

Although brutes have no articulate sounds, they have a language perfectly intelligible to one another. They make one noise to express joy, another terror, another to summon their young, &c., and comprehend the meaning of sounds made by us, not only of an inarticulate kind, but also articulated. The sagacity of some dogs in this respect is astonishing. "They learn to understand not merely separate words or articulate sounds, but whole sentences expressing many ideas. I have often spoken," continues Gall, "intentionally of objects which might interest my dog, taking care not to mention his name, or make any intonation or gesture which might awaken his attention. He, however, showed no less pleasure or sorrow, as it might be; and, indeed, manifested by his behaviour that he had perfectly understood the conversation which concerned him. I had taken a bitch from Vienna to Paris; in a very short time she comprehended French as well as German, of which I satisfied myself by repeating before her whole sentences in both languages." [k]

[i] *El. Physiol.* lib. viii. sect. iv. p. xxx—xl.

[k] *Sur les Fonctions du Cerveau,* t. v. p. 49. sq.

SECT. X.

OF ANIMAL HEAT.

163. Man, other mammalia, and birds, are distinguished from the rest of animals by the natural temperature[a] of their bodies greatly exceeding that of the medium in which they are accustomed to exist. Man is again distinguished from these classes of animals by possessing a much lower temperature than they; so that in this climate it is about 96° of Fahr., while in them, and especially in birds, it is considerably higher.[b] (A)

164. This natural temperature in man, is so constant, equable,[c] and perpetual, that, excepting slight differences from variety of constitution, it varies but a few degrees in the coldest climate and under the torrid zone. For the opinion of Boerhaave,—that man cannot live in a temperature exceeding his own, has been refuted, since the admirable observations[d] of H. Ellis, the celebrated traveller, and formerly the governor of Georgia, by the remarkable experiments[e] of

[a] W. B. Johnson, *History of Animal Chemistry*, vol. iii. p. 79.

[b] The torpid state of some animals, during winter, is of course an exception to this. During it most of the functions cease or languish considerably, and the animal heat is reduced nearly to coolness. This well-known circumstance prevents me from acceding to the opinion of the very acute J. Hunter, — that the animals which we call warm-blooded, should rather be called animals of a permanent heat under all temperatures. *On the Blood*, p. 15.

[c] J. B. Van Mons, *Journal de Physique*, t. lxviii. 1809. p. 121.

[d] *Philos. Trans.* vol. i. p. ii. 1758.

Arn. Duntze had previously made the observation in regard to brutes. *Exper. calorem animalem spectantia.* Lugd. Bat. 1754. 4to.

Consult also Benj. Franklin, *Experiments and Observations on Electricity.* Lond. 1769. 4to. p. 365.

[e] Duhamel and Tillet, *Mem. de l'Acad. des Scienc. de Paris.* 1704.

Blagden and Dobson, *Philos. Trans.* 1775.

many excellent physiologists.[f] (B) The striking prerogative of man in this respect is evinced by his being restricted to no climate, but inhabiting every part of the earth from Hudson's bay, where Mercury freezes, and from Nova Zembla, to the scorching shores of Senegal. (C)

165. The explanation of this equable and perpetual temperature is particularly simple and natural, and founded on the doctrine which makes the lungs the grand focus, and the decomposition of the oxygenised portion of the air (148) which we breathe, the fomes, of our heat.

166. For, as the oxygenous part of the inspired air is decomposed in the air-cells of the lungs, in such a way that its base, viz. oxygen, which by its union with *latent* caloric was before aëriform, now separates from this caloric; it would appear that, by this decomposition, one portion of the caloric is rendered sensible in the bronchiæ, while the other enters in a latent form into the blood while circulating in the innumerable and delicate net-works of the pulmonary vessels.[g]

167. When the oxygenised blood thus charged with latent heat circulates through the aortic system, it acquires carbon in the small vessels and sets free much of the latent heat which it had received: in this way is our animal temperature principally produced and modified.[h] (D)

168. Its production and regulation, however, appear much influenced by the *secretion* of the various fluids from the blood,

[f] The heat of the weather, even in Europe, occasionally exceeds our natural temperature. This was the case on the third of Aug. 1783, at noon, when I was on the Lucerne Alps, in company with the excellent Schnyder of Wartensee. The thermometer in the shade stood above 100° Fahr., and when applied to the body, invariably sunk to near 97°.

[g] See Lichtenberg's animadversions upon this part of Crawford's Theory, in his notes to Erxleben's *Anfangsgr. der Naturlehre.* p. 447. ed. vi.

[h] Hence the constant coldness of those wretched beings who labour under the *blue disease,* which arises from a mal-conformation of the heart. Sometimes the septa of the heart are imperfect, sometimes the aorta arises with the pulmonary artery from the right ventricle, as in the tortoise. In such instances, the chemical changes can take place in the lungs but imperfectly.

Consult a host of cases in J. C. Hein's *Diss. de istis Cordis deformationibus quæ sanguinem venosum cum arterioso miscere permittunt.* Gotting. 1816. 4to.

and by *digestion* as well as other functions of the animal economy.

169. Since the changes are effected by the energy of the *vital powers* only, the great influence of these in supporting our temperature must be easily perceived.[i]

170. Many arguments render it probable, that the action of the minute vessels is dependent upon the varied excitement or depression of the vital principle, and the conversion of oxygenised into carbonised blood, again, upon this.

For the remarkable phenomena of the stability of our temperature,[k] (proved by the thermometer, and not by the sense of touch, which may be fallacious) — that it is scarcely increased by the heat of summer, or diminished by the cold of winter, but found sometimes even to increase on immersion in cold water,[l] demonstrate that the action of the minute vessels varies according to the temperature of the medium in which we are placed: so that, when exposed to a low temperature (by which their tone is probably augmented) more oxygen is exchanged for carbon and more heat evolved, while in a high and debilitating temperature this exchange is diminished and less heat evolved.[m]

[i] I have formerly treated at some length of the influence of the nervous system upon animal heat, in my *Specimen Physiologiæ Comparatæ inter animantia calidi & frigidi sanguinis.* 1786. p. 23.

See the same confirmed by many arguments in Magn. Ström, *Theoria inflammationis doctrinæ de calore Animali superstructa.* Havn. 1795. 8vo. p. 30. sq. and by the much lamented Roose, *Journal der Erfindungen*, &c. t v. p. 17.

Consult also Dupuytren, *Analyse des Travaux de l'Institut.* 1807. p. 16.

But especially B. C. Brodie's *Experiments and Observations on the Influence of the Brain on the Generation of Animal Heat. Phil. Trans.* 1812. p. 378.

Also J. Davy, *Ibid.* 1814. t. ii. p. 590.

Wilson Philip, *Experimental Inquiry into the Laws of the Vital Functions*, 2d edit. Lond. 1818. 8vo.

[k] Consult Crawford, *Phil. Trans.* vol. lxxi. p. ii.

[l] G. Pickel, *Experimenta Physico-Medica de Electricitate et Calore animali.* Wirceb. 1788. 8vo. p. 91. sq.

[m] C. Ferd. Becker, *De Effectibus caloris et frigoris externi in c. h.* Gott. 1802. 4to.; and Wm. Fr. Baur, *On the same subject.* ib. eod. (both honoured with the royal prize.)

Mich. Skjelderup, *Dissert. sistens vim frigoris incitantem.* Hafn. 1803. 8vo.

171. The *corium*, which covers the body, and the internal surface of the *alimentary canal*, eminently contribute, if we are not much mistaken, to regulate our temperature.[n] For both these organs are supplied with an immense number of blood-vessels, being analogous in this respect to the lungs, and are so intimately connected with the lungs by means of sympathy,[o] as to be able to perform a part, and, for a time, the whole, of some of their functions in their room. This is exemplified in adults labouring under nearly total consumption or other violent affections of the lungs, and nevertheless, existing for a length of time almost without respiration.[p]

172. This opinion respecting the action of the *cutaneous* vessel in exciting, moderating, or almost extinguishing, our heat, receives much support from the physiological and pathological facts of *some parts* being frequently of a higher or lower temperature than the rest of the system.

Thus we must attribute the coldness of the dog's nose to the specific action of its own vessels being modified differently from that of the rest; so on the other hand, the burning at one time of the cheeks and of another of the palms of the hands in hectic fever, to a similar locally increased action of vessels; besides other phenomena of the same description, *v.c.* the heat of the genitals during the venereal œstrum, and the obstinate coldness of the feet in so many invalids.

173. The *alimentary canal* is the only internal part, besides the lungs, exposed to the contact of the atmosphere. There is scarcely occasion to prove that it is so exposed, and that we swallow a considerable quantity of air.

The air, when swallowed, is decomposed in the stomach and intestines, so that, during health, it soon loses its elastic form: not, however, when the capillaries of the canal are debilitated, nor when it exists in too great quantity.

[n] J. Chr. Goeschen, (Præs. Ph. Fr. Meckel) *Pulmonum cum Cute commercium*. Hal. 1789. 8vo.

But especially J. D. Brandis, *Pathologie*. Hamb. 1808. p. 316. sqq.

[o] Consult, for instance, Tacconi, *Comment. Instit. Bononiens.* vol. vi. p. 74.

[p] M. W. Plagge, *über die im darmcanal stattsindende respiration*; in Meckel's *Archiv.* t. v. p. 89.

The immense congeries of blood-vessels in the intestines on their internal surface which is usually thought equal to the external surface of the body, agrees very well with this idea.

NOTES.

(A) All animals, as far as can be ascertained, and even vegetables, have a tendency to preserve a temperature more or less distinct from that of the surrounding medium ; yet the difference among them in this respect is so great that they have been divided into warm and cold-blooded. To the former belong the more complicated, those whose pulmonary apparatus is most elaborate, — man and mammiferous quadrupeds and birds. To the second, oviparous quadrupeds, fish, and most of the invertebrate. Birds have the highest temperature, — 107° to 110° ; mammiferous quadrupeds, 100° to 101° ; man 96° to 98½°. There is some variety, not only in individuals, but according to age, season, and climate. It is less in the young, according to Dr. Edwards and Despretz : [q] the former states the human temperature in infancy to be 94¼° ; the latter asserts, that while in birds it is 105° in winter, it is nearly 111° in summer, gradually increasing in spring and decreasing in autumn. In the high temperature to which we shall see Dr. Fordyce and his friends were exposed, the temperature of the body rose two or three degrees, and Dr. Delaroche in a vapor-bath at near 120°, found the heat under his tongue increased but about five degrees at the end of seventeen minutes.[r] In sparrows and yellow-hammers Dr. Edwards found it five or six degrees higher in summer than in winter ; and Dr. Davy one or two degrees higher in Ceylon than in England.[s] In disease it will fall, and on the other hand rise ; in fever it has been noted at 107°, in tetanus at 110°,[t] and probably, on some occasions, it rises still higher, at least, locally. In old age it is not so high as in the

[q] *De l'Influence des Agens Physiques. Edinburgh Journal of Science,* vol. iv. p. 185. J. Hunter states that the temperature of the ass is one degree higher in the evening than the morning. *On the Blood,* p. 298.

[r] *Exp. sur les effets qu'une forte chaleur produit sur l'economie.* Paris, 1805.

[s] Edwards, l. c, p. 489.

[t] Dr. Prevost. See Edwards, l. c. p. 490.

age of full vigour; nor in remote parts as in those nearer the heart.[u] John Hunter made observations on the heat of cold-blooded animals.[v] The thermometer in the stomach and under the skin of the abdomen of the frog and toad stood at 40°, when the atmosphere was 36°; in the lungs of snails at 35°, 36°, 37°, 38°, when the atmosphere was 28°, 30°, 30°, and 34°; the heat of earth-worms was 58½°, when the atmosphere was 56°. Fish are not above two degrees warmer than the water.[w] Cold-blooded animals placed in an elevated temperature are much more influenced by surrounding media than the warm-blooded. Yet frogs are but at 80° or 82° in a medium of 110° or 115°.[x] The heat of insects when congregated is considerable: J. Hunter found the thermometer rise to 93° or 98° in a hive of bees in spring; to 104° in summer; to be at 82° when the air was at 40°; and at 73° in winter.

The same tendency in vegetables is shown by the greater difficulty with which the juices in their stems and branches are frozen than lifeless fluids; by ice thawing when roots shoot into it;[y] and by snow upon the leaves or stems of plants thawing sooner than that which lies on surrounding inanimate bodies. J. Hunter observed a branch of growing fir and a bean leaf thaw the part of the surface of a freezing mixture on which it was placed, and the fir subsequently another to which it was removed.[z] When the sheath of the arum maculatum and cordifolium is bursting and the cylindrical body just peeping forth, it is said, by Sennebier, to be so hot for some hours as to seem burning;[a] and twelve of them placed round the bulb of a thermometer to have raised the mercury from 79° to 143°.

Even eggs are cooled and frozen with more difficulty than equal masses of inanimate matter; although, when once frozen and their life destroyed, they freeze readily.[b]

[u] Dr. Davy, *Phil. Transact.* 1814.

[v] l. c. 298. sqq.

[w] *Edinburgh Journal of Science*, vol. iv.

[x] Dr. De la Roche, *Journal de la Physique*, t. lxiii.

[y] *American Medical and Philosophical Register*, vol. iii. p. 19. 1814.

[z] *Phil. Trans.* 1775.

[a] *An Introduction to Physiological and Systematic Botany.* By Sir J. E. Smith, M.D. p. 92.

[b] Hunter, l. c. p. 79.

(B) Dr. Fordyce, one of the most eminent of my predecessors at St. Thomas's Hospital, went successively into three rooms heated to 90°, 110°, and 120°. In the first he staid five minutes, and sweated gently.—In the second, he sweated more profusely, and remained ten minutes.—In the third, after remaining twenty minutes, the thermometer under the tongue and exposed to the urine was at 100°; the pulse 145°; the veins of the surface were enlarged, and the skin red. He afterwards entered a room heated to 130°, and staid 15 minutes: the thermometer under the tongue, in the hand, and exposed to the urine, was at 100°.

Sir Joseph Banks, Sir Charles Blagden, and Dr. Solander, went subsequently into rooms heated to between 96° and 211°, — the temperature of boiling water, and remained several minutes. If they breathed on the thermometer it sunk several degrees, and every expiration felt cold to the scorched nostrils: the thermometer under the tongue was 98°, and the body felt cold to the touch, though at 98°. Sir C. Blagden remained eight minutes in an apartment heated to 260°. The air felt hot, and for seven minutes the breathing was natural, but anxiety and oppression then came on; the sensible heat of the body varied but little. Dr. Dobson went into a room heated to 224, and felt no oppressive heat, though every metal about him speedily became hot. A bitch of moderate size was subjected to a heat of 220°. In ten minutes the only sign of distress was that of holding out the tongue, and when taken out at the end of half an hour, the temperature being at 236°, the bottom of the basket was found wetted with saliva. The thermometer applied to her flank was only 110°, *i. e.* 9° above the natural standard.

In these rooms, eggs on a tin plate were roasted hard in twenty minutes; beef steaks cooked in thirty-three minutes; and if the air was impelled upon them in a stream, they were cooked dry in about thirteen minutes.

Tillet and Duhamel relate that the young female servant of a baker at Rochefoucault went habitually into ovens heated to 276°, and remained without great inconvenience for twelve minutes, taking care not to touch the oven. These gentlemen themselves bore a heat of 290° for nearly five minutes. Dr. Delaroche and Dr. Berger found various warm and cold-blooded animals support from 108° to 113° for an hour and a half in heated dry air; but an elevation of about 30° beyond this kill them all except a frog, in from half an hour to two hours. They themselves experienced a sense of scalding in a *vapour*-bath of 122°, and could not bear it more than about ten minutes; while M. Lemonnier could not bear a *water*-bath of 113° above eight minutes.[c] Hence, at the very same high temperature of the surrounding medium, there is more secretion by the skin in a vapour-bath than in dry air, and more in a water-bath than in a vapour-bath.

(C) At Sierra Leone the mean temperature is 84°, and Watt and Winterbottom frequently saw it 100° and even 103° in the shade. At Senegal it has been 108½° and even 117½°. During the sirocco it is 112°, in Sicily; Humboldt saw it 110° and 115° near Oronoco, in South America. On the other hand, at Nova Zembla the cold is so intense that when the sun sinks below the horizon the polar-bear is no longer seen, the white fox only enduring the cold. Yet the Dutch, who wintered there under Hemskerk (76° N. L.) withstood the cold if moving about and previously in good health. When some of our countrymen were on Churchill river, in Hudson's Bay, lakes ten or twelve feet deep were frozen to the bottom, and brandy froze in their rooms, though provided with fires. They suspended in their rooms red hot twenty-four pounders, and kept an immense fire; but if these went down, the walls and beds were covered with ice three inches thick.[d] Yet in Hudson's Bay the Canadians and Esquimaux live and hunt in the coldest weather. Gmelin, sen. witnessed at Jenisiesk, in 1735, a cold of 120° below zero, that froze mercury and killed all the sparrows and jays.[e] Captain Parry once observed a temperature of 52° below zero. When the air was at —49° the party used to walk on the shore. It was usually at —32°. The temperature of eleven out of sixteen foxes was from 100° to 106¾, of four about 100°, and of one only 98°, although the air was from —3° to —32°. No relation was observable between the temperature of the body and of the atmosphere;[f] it thus appearing that the temperature is more steady under cold than heat. Some cold-blooded animals bear heat very badly. Dr. Edwards says that frogs die in a few seconds in water at 107°.[g] Yet a species of tænia has been found alive in a boiled carp;

[c] Edwards, l. c. p. 374. and indeed, see p. iv. ch. xiv.
[d] *Philosophical Transactions,* abridged, vol. iii. p. 470.
[e] *Flora Siberica.* Preface.
[f] *Journal of a Second Voyage,* p. 157.
[g] l. c. p. 40.

but then the carp which it inhabits will live in water as hot as human blood.[h] Some of the lowest animals appear intended for high temperatures. Dr. Reeve found living larvæ in a spring at 208°; Lord Bute, confervæ and beetles in the boiling springs of Albano, that died when plunged into cold water.

The germs of many insects, &c. are unaffected by a great range of temperature. I know a gentleman who boiled some honey-comb two years old, and, after extracting all the sweet matter, threw the remains into a stable, which was soon filled with bees. Body lice have appeared on clothes which had been immersed in boiling water. Spallanzani found long ebullition in the open air favourable to the appearance of the animalcules of vegetable infusions, and the application of great heat in close vessels, although it prevented the appearance of a larger kind of animalculæ, did not that of a smaller. The eggs of silk-worms and butterflies hatch after exposure to a cold of 24° below zero. On the other hand, insects may be frozen repeatedly, and recover as soon as thawed, as we shall see when speaking of torpidity.

(D) No phenomenon in living bodies is more remarkable than their peculiar temperature, and no one was of more difficult explanation before the modern progress of chemistry. Dr. Mayow had indeed advanced, that it depended on respiration, and that this was a process similar to combustion, and so far from cooling the blood, as others believed, supplied it with heat.

If two different bodies are placed in a temperature higher or lower than their own for a certain length of time, they will, at the end of the period, be found not of the same, but of different temperatures. That which has the higher temperature is said to have a smaller capacity for caloric; that which has the lower, a greater capacity. To raise the former to a given temperature, therefore, requires less caloric than to raise the latter to the same degree.

The temperature of solids is more easily affected by a given quantity of caloric, than that of fluids, and the temperature of fluids than that of aëriform bodies: or, in other words, solids have a smaller capacity for caloric than fluids, and fluids than aëriform bodies. If, therefore, a solid becomes fluid, or a fluid aëriform, it absorbs a great quantity of caloric, notwithstanding its temperature remain precisely the same. And the converse holds

[h] Sennebier, *Notes to his Translation of Spallanzani.*

equally good,—if an aëriform substance becomes liquid, or a liquid solid, the caloric which it before contained is now (from its diminished capacity) much more than sufficient for the temperature which before existed, and the temperature of the body accordingly rises.

In respiration, the dark blood of the pulmonary artery parts with a portion of its carbon and acquires a florid hue. Oxygen disappears and carbonic acid is expired with the other constituent of the atmosphere,—nitrogen or azote, which appears generally to have experienced little or no change from inspiration.

The celebrated Dr. Crawford of St. Thomas's Hospital appeared to prove, by his experiments, that the arterial blood has a larger capacity for caloric than the venous, and common air than carbonic acid gas. When, therefore, the carbonic acid appears in the lungs, the smaller capacity of this than of common air for caloric, must cause an increase of temperature; but the blood, having changed from venous to arterial, has acquired a greater capacity than before, and absorbs the heat given out by the carbonic acid. The blood, of course, does not become warmer, because the caloric is not more than sufficient to render its temperature equal to what it was previously; and indeed, according to some, it is not quite sufficient for this, since the temperature of the arterial blood of the pulmonary veins has appeared two degrees lower than that of the pulmonary artery to some experimenters, although the greater number have found it a degree or two higher than the venous.

The body in this way acquires a fund of caloric, and yet the lungs, in which it is acquired, do not experience any elevation of temperature, or if they do, this is very inconsiderable.

The arterial blood, charged with much caloric, which, as it circulates through the small vessels, is not sensible, becomes venous,—acquires a dark hue, and its capacity for caloric is diminished; consequently its temperature rises,—the caloric which was previously latent, is, from the decrease of capacity, sufficient to raise its temperature, and is evolved. In this mode, the loss of caloric which occurs from the inferior temperature of the medium in which we live, is compensated. The fresh supply is taken in at the lungs, and brought into use in the minute vessels.

Of late this theory has fallen into some discredit.

All experiments upon the capacities of bodies for heat are very delicate and liable to error; and the conclusions of Crawford on this point have been denied by Drs. Delaroche and Berard, with respect to gases, and by Dr. Davy, with respect to arterial and venous blood.[i]

The experiments of these chemists have led them to believe the difference of capacity less than Crawford supposed, and insufficient to account for animal temperature. With respect to the gases, Dr. Bostock[k] justly remarks, that the objection does not apply more to the doctrine of animal heat, than to the theory of combustion in general. Whenever carbon unites with oxygen, and carbonic acid is produced, caloric is liberated, whether in fermentation, or combustion, &c. With respect to the blood, he declares, and Dr. Bostock's reputation for accuracy and soundness in chemical matters is not little, that "after attentively perusing the experiments of Crawford, and comparing them with those that have been performed with a contrary result, he confesses that the balance of evidence appear to him to be greatly in favour of the former, though he acknowledges that they are of so delicate a nature as not to be entitled to implicit confidence, and that it would be extremely desirable to have them carefully repeated."

If, however, it were true that Dr.Crawford's statement of the relative capacities is incorrect, still the fact of heat being necessarily evolved on the disappearance of oxygen in the lungs, and the appearance of carbonic acid, would stand unaffected, and we should only be obliged to adopt the doctrine of Mayow, that the lungs are the focus of the heat of the body. This was relinquished on the objection that the lungs should then be hotter than other parts. But when we consider that the blood is incessantly streaming to the lungs from all parts, and again leaving them, we may, I think, presume that the blood will always convey away their heat, and prevent their temperature from rising above that of other parts. The heat of all parts is, cæteris paribus, commensurate with the quantity of blood circulating through them. This is equally explicable on either supposition. If their heat is derived from the heat of the blood conveyed to them, the more blood streams through them, the hotter will they be; if from chemical changes

[i] *Philos. Trans.* 1814.

[k] l. c. vol. ii. p. 263.

in the blood while in them, the more blood streams through them, the greater will be the amount of chemical change, and the greater the extrication of caloric. The quantity of blood is inefficient unless constantly renewed, on either supposition. On the first, fresh blood must come incessantly from the lungs with its high temperature; on the second, if not renewed, the chemical changes will cease, having already occurred.

A host of circumstances show that our temperature depends upon respiration, and therefore upon chemical changes.

In high temperatures we have less necessity for the evolution of heat; in low temperatures, more. Accordingly, in the former, the arterial blood remains arterial, — is nearly as florid in the veins as in the arteries, and the inspired air is less vitiated; in low temperatures, the venous blood is extremely dark, and the inspired air more vitiated.[l] Some have imagined that the body remains at its standard high temperature by the refrigeration of the evaporating sweat. But though this must contribute, it is not the sole cause:[m] for frogs lose as much proportionally to their size by evaporation as any other animal, yet they follow pretty closely the surrounding temperature. Whenever, on the other hand, the body itself heightens its temperature, as in fever, more oxygen is consumed by the lungs;[n] (in the cold stage of fevers we saw that less was consumed). The temperature of the various classes of animals, and their vitiation of the air, are always proportional; and inverse to the length of time they can live without air.

The temperature of young animals is lower than of adults, or rather they maintain a peculiar temperature much less, and they vitiate the air less, and require respiration less, proportionally, than adults.[o] As they proceed to vitiate it more, and require respiration more, their calorific power increases. While their calorific powers are weak they breathe, if they are exposed to cold, quicker, so as to keep up their temperature as much as possible.[p] The same is also found in adult warm-blooded animals, not of the hybernating family, when exposed to cold.[q]

[l] Crawford, l. c. p. 387. sq.
[m] Edwards, l. c. p. 488.
[n] See supra, p. 133.
[o] Edwards, l. c. p. 165. sqq.
[p] Edwards, l. c. p. 299. 310.
[q] l. c. p. 301.

Dr. Edwards found that habit has great influence on the calorific powers of animals; — that a given low artificial temperature in winter will reduce the animal heat much less than in summer:[r] and that with the habit of evolving more heat in winter, is acquired the habit of consuming and requiring more oxygen, so that animals supplied with a given quantity of air, and placed in a given warm temperature in winter, die much sooner than in summer.[s] Yet the *momentary* application of heat or cold has a different effect: the former heating less if the body has been subjected to a low, and the latter cooling less if the body has been subjected to a high, temperature. We all feel the cold less quickly on leaving the house in winter if well warmed first, than if we leave it already chilly.

When animals hybernate, their temperature falls, and respiration is nearly or entirely suspended.[t] Their consumption of air lessens as the temperature falls, whence they consume less in November than in August.[u] If hybernating animals, while torpid and still placed in the same temperature, are stimulated mechanically to breathe, their temperature rises with the progress of respiration.[x]

If the cold to which they are exposed is so intense that it threatens death, it actually no longer depresses respiration, but for a time, excites it, and their temperature rises proportionally.[y] Man, and other non-hybernating animals, breathe more quickly when exposed to cold, no doubt for the purpose of supplying heat, till the powers become exhausted.[z]

The higher the temperature of the animal, the more extensive is the aggregate surface of the air-cells, the more blood passes through its lungs, and the more necessary to its existence is respiration. — The lungs of cold-blooded animals are not subdivided into minute cells, but formed into vesicles; and birds, which have the highest temperature among animals, are drowned the soonest.[a]

[r] l. c. p. 162. sqq. 252. sqq. [s] l. c. p. 200. sqq.

[t] Spallanzani, *Mémoires sur la Respiration*, p. 77. De Saissy could not by cold produce torpor in a marmot, till he had deprived it of fresh air. Edwards, l. c. p. 154.

[u] M. de Saissy. See Edwards, l. c. p. 286.

[x] M. De Saissy. See Edwards, l. c. p. 305.

[y] l. c. p. 306. sq. [z] l. c. p. 301.

[a] Boyle's *Works*, vol. iii. p. 368.

The changes of the air by the blood, are seen to be effected entirely by the red particles. Prevost and Dumas found that the number of red particles is proportionate to the temperature.

If the blood circulates without being first properly changed in the lungs, the temperature is below the natural standard. Those who have the blue disease (cœruleans [b]), as Blumenbach notices (p. 155), are cold: and coldness is a symptom of hydrothorax, and of the repletion of the air-cells with mucus in chronic bronchitis; in the former of which affections the lungs cannot fully expand, and in the latter the air is prevented from coming fully in contact with the air-cells.

In cold climates, and in temperate ones in cold weather, animal food is desired and taken in abundance; in hot climates, and during the summer in temperate regions, light vegetable food is preferred, and the appetite is less. We may conceive the former diet more calculated to support a process similar to combustion, and under the former circumstances we have seen that the changes of the air in the lungs are actually more considerable.

The temperature of parts falls if not maintained by a constant stream of blood from the lungs through the aorta and its ramifications, and is, cæteris paribus, in exact proportion to this supply.

Whether Crawford's theory be correct or not, the production of animal heat must be as evidently a chemical process, as changes of temperature among inanimate bodies; yet some ascribe it to nervous energy. I cannot imagine nervous energy to cause heat any more than to cause chemical affinity. As it may bring substances together which have an affinity for each other, and thus produce their union, so it may effect those changes which are, according to physical laws, accompanied by changes of temperature; but caloric in the body must, I apprehend, like affinity, follow the same laws, and no others, as out of the body. This, however, does not prevent animal temperature from deserving the epithet vital, because it is regulated by the vital powers of the system, although through the instrumentality of chemical changes. If the high temperature of an inflamed part is owing to the increased momentum, — the increased sum of the quantity and velocity of its blood, — yet this increased momentum is produced by the vital powers.

[b] Mr. Allan Burns, *Essay on Diseases of the Heart*, and Dr. Farre's *Treatise on Malformation of the Heart*, give excellent accounts of these cases.

Mr. Brodie removed the brain of animals, and continued respiration artificially. The usual chemical changes of the blood continued in the lungs; yet the temperature of the animals diminished, and even more rapidly than if the respiration had not been continued, owing, it is said, to the succession of cool air sent into the lungs. He therefore concludes, that animal heat depends much more upon the nervous energy than upon the chemical changes of the blood.[c] But this experiment proves nothing, because Dr. Le Gallois asserts, that under artificial respiration the temperature may fall, and the animal actually be killed by cold, even though every part remain uninjured.[d] In artificial respiration the air does not rush into the pulmonary cells, because these are in a vacuum, but is propelled into, and forcibly and therefore injuriously dilates, them; the consequence is, the formation of a large quantity of frothy mucus. Whether the fall of temperature be owing to the evaporation of this copious secretion and its prevention of contact between the air and air-cells, or to the injurious nature of artificial respiration, still the fact ascertained by Le Gallois destroys the conclusion which appeared deducible from Mr. Brodie's experiment. Indeed, Le Gallois found, that less oxygen was consumed than in natural breathing, and that the temperature fell exactly in proportion to the smallness of the quantity of oxygen consumed. Dr. Crawford himself stated, that the chemical process of respiration may, in certain cases, be the means of cooling the body. If the pulmonary exhalation, he said, is in very great abundance, it will carry off so much of the heat given out during the change of the oxygen into carbonic acid, that there may not be sufficient to saturate the increased capacity of the arterial blood: this, therefore, will absorb caloric from the system, as it passes along, till its temperature equals that of all parts.[e] I may here remark, that the tem-

[c] *Phil. Trans.* 1812.

[d] *Expériences sur le Principe de la Vie.*

[e] *On Animal Heat*, p. 388. Instances are recorded by Morgagni (iv. xlix. 26.) and De Haen (*Ratio Medendi*, vol. iii. p. 36.), and Mr. Thackrah, of the blood which streamed down the extremity in venesection feeling cold to the patient and the practitioner. One woman compared it to ice; and the sensation given to Mr. Thackrah was the same as that of water at 68°. (Thackrah, *On the Blood*, p. 87.) The stomach of a cod was found by Dr. Mosely to be not only colder than the water from which it was taken, and the rest of the fish, but painfully to benumb the hand. (*Diseases of Tropical Climates.*) Similar observations were made at Newfoundland, and are quoted by Professor Rudolphi. (*Grundriss der Physiologie*, 182.)

perature is kept down in a heated atmosphere by the diminution of chemical changes in the lungs, and by free secretion and evaporation from the bronchiæ and skin. How much each contributes is not ascertained; but the importance of evaporation was shown in some experiments of Dr. De la Roche, who raised the temperature of animals considerably by placing them in a heated atmosphere loaded with moisture, thus preventing evaporation. In a cold atmosphere, the chemical changes in the lungs are great, and the skin is dry; the aqueous matter which leaves the body then, does so by the kidneys, in a fluid form, and even in much less quantity, because our thirst, and the amount of our drink, are much less.

Dr. Philip has made experiments equally conclusive with those of Dr. Le Gallois against the inferences drawn by Mr. Brodie. As very little air is taken into the lungs in natural inspiration, and a regard to the bulk and frequency of each inspiration not always attended to in experiments, it is very probable that that gentleman had thrown too much air into the lungs, so that the unnatural quantity of cold air, and the augmented secretion of bronchial fluid, made the temperature fall. By impelling little, and that not frequently, Dr. Philip found that artificial respiration, after the destruction of the brain, actually retarded the cooling of the animal, while stronger respiration did actually cool the body.

Of two rabbits killed in this way, their temperature being 104°, one was subjected to 6 artificial inspirations, and the other to from 26 to 30, in a minute: the temperature of the former was 100° at the end of an hour, and the latter 98°. Of two, with the temperature of 102.5°, one was undisturbed, and one subjected to about 30 inspirations in a minute: the temperature of the former at the end of half an hour was 98.75°; of the latter, only 98.5°. But the lungs of the latter being now inflated but about twelve times in a minute, the temperature of the former at the end of another half hour was 95.25°, and of the latter, 96°. In one experiment, in which the lungs were inflated but a few times in a minute, the temperature actually rose nearly a degree by artificial respiration.[f] Dr. Hastings, at the same time, made similar comparative experiments, and with similar results. In one, the rabbit in which artificial breathing was performed, cooled only 4°; while that which was left undisturbed cooled 7.5°.

[f] *An Experimental Inquiry into the Laws of the Vital Functions.* 3d edit. p. 180. sqq.

Dr. Philip afterwards took pairs of rabbits, killed them in the same way, and then in one experiment destroyed the brain and spinal marrow of one with a wire, while he left the other untouched: in another, precisely similar, he inflated the lungs of both. Yet, in each experiment, they both cooled equally. In a third, the brain and spinal marrow of one only was destroyed, and the lungs of both inflated. These, too, cooled equally.

The temperature of fœtuses born without brain is maintained during the few days they may live.

Professor Rudolphi remarks, that the temperature of animals bears no proportion to their nervous system: that if it did, man should be warmer than any brute; the mammalia much more so than birds; fish much more so than insects; and birds and amphibia nearly upon a par; — all which would be the reverse of fact.[g]

Vegetables have a tendency to preserve a peculiar temperature, yet they have no nervous system.

But that the nervous system affects the temperature is certain: a passion of the mind will make the stomach or the feet cold, or the whole body hot. Paralysed parts are often colder than others, or, more properly, are more influenced than others by all external changes of temperature.[h] But every function is affected by the mind, though not dependent upon the brain for its regular performance. And in varieties of temperature, both by the state of the mind, and by paralysis, there is, as far as we can judge, a commensurate affection of the local circulation. Parts heated by any passion are also red, and *vice versâ;* and paralytic parts must have imperfect vascular functions, in some measure at least, from the want of the compression of the vessels by muscular action, and of the general excitement by volition; they waste, and sometimes inflame and ulcerate, or slough, on the slightest injury. And parts perfectly paralysed still maintain a temperature above that of the surrounding medium, as well as circulation, secretion, &c.[i] and sometimes the same as in health.

[g] *Grundriss der Physiologie,* 150.

[h] Dr. Abercrombie, *Edin. Med. and Surg. Journal.*

[i] Dr. Philip, we have seen, found rabbits just killed cool in exactly the same time, whether the brain and spinal marrow were destroyed or not, although where they were destroyed a stop was put to the secretion of gastric juice. Yet when the same was done to a living rabbit, with the same effect on the stomach, the animal's temperature fell. This, however, would result from the shock given to the nervous system as merely a part of the body, as we see every day in cases of severe injuries even of the extremities.

Dr. Philip considers galvanism an important agent in the nervous system, and found that it raised the heat of *fresh arterial* blood 3° or 4°, and, at the same time, made the blood venous; a circumstance proving that the action is purely chemical, — an alteration of the blood to that state in which its capacity for caloric is less.[k]

There is certainly no more reason to believe animal heat dependent on the nervous system, than secretion and every organic function. That, like these, it is influenced by the state of the nervous system, is certain; but never, I imagine, except through the instrumentality of chemical changes.

Besides the power of generating heat, animals are luminous, and display electric phenomena.

The glow-worm is known to all, and many insects of the beetle tribe, as well as others, emit light. Many can extinguish or conceal their light, or render it more vivid, at pleasure. In some it has been found to proceed from masses not dissimilar, except in their yellow colour, from the interstitial substance of the rest of the body, lying under the transparent integuments, and absorbed when the season of luminousness is passed.[l] The ocean is frequently luminous at night from the presence of certain animalcules, to some sort of which, perhaps, is owing the phosphorescence of dead herrings. Some fish, as the gymnotus electricus and torpedo, give electric shocks, and possess a regular galvanic battery.

I have adopted the common language in speaking of animal heat, as though the phenomena depended upon a specific substance. But there is every reason to believe that neither caloric nor light are fluids, but peculiar states only; and electricity will probably prove so likewise, and, indeed, all these to be but modifications of the same state.

[k] *Experimental Enquiry*, p. 230. sqq.

[l] Consult Kirby and Spence, *An Introduction to Entomology*, vol. ii. p. 409. sqq.

SECT. XI.

OF PERSPIRATION.

174. The functions of the skin, which affords a covering to the body, are so extremely various, that they cannot all be easily described with advantage in one chapter, but each will be considered far more conveniently under that class of actions to which it belongs.

For, in the first place, the skin is the organ of touch, and will be examined in this view, under the head of animal functions.

It is an organ of inhalation, and in this point of view belongs to the absorbent system, to be spoken of among the natural functions.

It is likewise the organ of *perspiration*, and on this account is related in many ways to the function of respiration, and may, we think, very properly follow it in this place.

175. The skin consists of three membranes — The *corium*, internal; the *cuticle*, external; and the *reticulum*, intermediate.

176. The *cuticle*, or epidermis,[a] forms the external covering of the body, is separable into several lamellæ,[b] and exposed to the atmosphere, the contact of which can be borne by scarcely any other part, if you except the enamel of the teeth. For this reason, the internal cavities, and the canals which communicate with the surface for the purpose of admitting air, especially the respiratory passages and the whole of the alimentary canal, the tongue, the inside of the cheeks, the

[a] Al. Monro (Primus), Oratio *de Cuticula Humana*. Opera. English edition. Edinb. 1781. 4to. p. 54. sq.

[b] Among others, consult J. Mitchell, *Philos. Trans.* vol. xliii. p. 111.

fauces, and the organ of smell, are covered by a fine epithelium, originating from the epidermis. [c]

177. The texture of the epidermis is extremely simple, destitute of vessels, nerves, and of true mucous web, and consequently but little organised; very peculiar, however; [d] remarkably strong, considering its pellucidity and delicacy, so that it resists suppuration, maceration, and other modes of destruction, for a great length of time; and reproduced more easily than any other of the similar parts.

178. It is completely sui generis, somewhat like a horny lamella, and adheres to the subjacent *corium* by the intervention of a mucus, and by numerous very delicate fibrils which penetrate the latter. [e]

The pores, which Leuwenhoek imagined in it, do not exist; but it allows a very ready passage to caloric, carbon,

[c] Abr. Kaau, *Perspiratio dicta* Hippocrati, p. 7.

Lieberkühn, *De fabrica Villor. Intestin. Tenuium*, p. 16.

Cruikshank, *Expts. on the Insensible Perspiration*, p. 5.

Rudolphi, *Reisebemerkungen*, t. i. p. 29. 140.

Jens. W. Neergaard, *Vergleichende Anat. der Verdauungswerkzeuge*, p. 21, et alibi.

J. B. Wilbrand, *Hautsystem in allen seinen Verzweigungen*. Giessen. 1813. 8vo.

[d] The very dense epidermis of some immense animals consists of vertical fibres, which, in arrangement, somewhat resemble the structure of the Boletus igniarius. Its internal surface is porous, and penetrated by the silky filaments of the subjacent corium. This is remarkably exemplified in a preparation now before me, taken from the skin of the balæna mysticete.

The human cuticle, in certain diseased states, exhibits the same appearance as in the Englishman called the Porcupine Man, who laboured under a cutaneous complaint which he transmitted to his children and grand-children. Vide W. G. Tilesius, *Beschreibung und Abbildung der beiden sogenannten Stachelschwein-Menschen* (Porcupine Men.) Altenb. 1802. fol.

The innumerable polyedrical papillæ and horny warts which I witnessed upon every part of the skin of these brothers, excepting the head, the palms of the hands, and the soles of the feet, bore some resemblance to the skin of the elephant, especially about the vertex and forehead of the animal. (A)

Similar also are corns and the brawny cuticle of the feet in those who walk barefooted. Vide Carlisle on the Production and Nature of Corns, *Med. Facts and Observations*, vol. vii. p. 29.

[e] W. Hunter, *Med. Observations and Inquiries*, vol. ii. p. 52. sq. tab. i. fig. 1, 2. The conjecture of this eminent man, — that these fibrils are *vessels* which excrete the perspirable matter, is, I think, improbable.

hydrogen, and to matters immediately composed of these, *v. c.* oil.

179. The importance of the cuticle to organised systems, is demonstrated by its universality in the animal and vegetable kingdoms, and by its being distinctly observable in the embryo from the third month at latest after conception.

180. The inner part of the cuticle is lined by a fine mucous membrane, denominated, from the opinion of its discoverer, *reticulum Malpighianum*, and by means of which chiefly the cuticle is united more firmly to the corium.[f]

Its nature is mucous, it is very soluble, and, being thicker in Ethiopians, may be completely separated in them from both the corium and cuticle, and made to appear as a true distinct membrane.[g] (B)

181. Our colour resides in it. In all persons the corium is white, and, in almost all, the cuticle white and semipellucid, though in Ethiopians it inclines to grey. But the mucous reticulum varies after birth, with age, mode of life, and especially with difference of climate.

Thus among the five varieties into which I would divide the human race, in the first, which may be termed Caucasian, and embraces Europeans (except the Laplanders and the rest of the Finnish race), the western Asiatics, and the northern Africans, it is more or less *white*.

In the second or Mongolian, including the rest of the Asiatics (except the Malays of the peninsula beyond the Ganges), the Finnish races of the north of Europe, as the

[f] Hence I have found the epidermis of *Albinoes* separate easily by the heat of the sun; whereas, in negroes, it scarcely does so on the application of a blister. Consult Mitchell, l. c. p. 108.

[g] B. S. Albinus, *De sede et causa coloris æthiopum et cæteror. hominum.* Lugd. Batav. 1737. 4to. fig. 1.

Sam. Th. Soemmerring, *über die körperl. Verschiedenh. des Negers vom Europäer.* Ed. 2. p. 46. sq.

Some even of the moderns have assigned many laminæ, and even different species, to the reticulum; as Lieutaud, *Essais Anatomiques*, p. 103. ed. 1766.

Cruikshank, l. c. p. 43. 99.

But especially G. A. Gualtier, *Recherches Anatomiques sur le Système cutané de l'Homme.* Paris, 1811. 4to.

Laplanders, &c. and the tribes of Esquimaux widely diffused over the most northern parts of America, it is *yellow* or *resembling box-wood.*

In the third or Ethiopian, to which the remainder of the Africans [h] belong, it is of a *tawny* or *jet black.*

In the fourth or American, comprehending all the Americans excepting the Esquimaux, it is almost *copper coloured*, and in some of a *cinnamon*, and, as it were, *ferruginous* hue.

In the fifth or Malaic, in which I include the inhabitants of all the islands in the Pacific Ocean, and of the Philippine and Sunda, and those of the peninsula of Malaya, it is more or less brown, — between the hue of fresh mahogany and that of cloves or chesnuts.

All these shades of colour, as well as the other characteristics of nations and individuals, run so insensibly into one another, that all division and classification of them must be more or less arbitrary.

182. The essential cause of the colour of the Malpighian mucus, is, if we mistake not, the proportion of carbon which is excreted together with hydrogen from the corium, and which, in dark nations, being very copious, is precipitated upon the mucus, and combined with it. [i]

183. The *corium*, which is covered by the reticulum and epidermis, is a membrane investing the whole body, and defining its surface; tough; very extensible; of different degrees of thickness; every where closely united, and, as it were, in-

[h] Jo. Nic. Pechlin, *De Habitu et Colore Æthiopum, qui vulgo et Nigritæ.* Kilon. 1677. 8vo.

Camper's oration on the same subject will be found in his *Kleiner Schriften,* vol. i. P. i. p. 24—49.

[i] I have given this opinion at some length, in my work, *De Gen. Human. Varietate Nativa,* p. 122. sq. ed. 3. Some eminent chemists accord with me, among whom suffice it to mention the celebrated Humphry Davy, *Journals of the Royal Institution,* vol. ii. p. 30. "*In the rete mucosum of the African, the carbon becomes the predominant principle; hence the blackness of the negro.*" W. B. Johnson, l. c. vol. ii. p. 229.

F. B. Osiander has given an abundance of very careful observations upon the various proportions of the carbonaceous element in the Malpighian mucus. *Comment Soc. Reg. Scientiar. Gotting. recentiorum,* vol. iv. p. 112. sqq.

terwoven, with the mucous tela, especially externally, but more loosely on its internal surface, in which, excepting in a few regions of the body, we generally discover fat.

184. Besides *nerves* and *absorbents*, of which we shall speak hereafter, innumerable blood-vessels penetrate to its external surface, upon which they are shown, by minute injection, to form very close and delicate net-works.

185. A vast number of *sebaceous follicles* also are dispersed throughout it, and diffuse over the skin an oil, which is[k] very thin, limpid, does not easily dry,[l] and is altogether distinct from the common sweat, and from that which possesses an odour resembling the smell of goats and is peculiar to certain parts only.

186. Lastly, almost every part of the corium is beset with various kinds of *hairs*,[m] chiefly short and delicate, more or less downy, and found nearly every where but on the palpebræ, penis, the palms of the hand, and the soles of the feet. In some parts, they are long and destined for peculiar purposes; such are the capillamentum, the eye-brows, the eye-lashes, the vibrissæ, mustachios, beard, and the hair of the arm-pits and pudenda.

187. Man is, generally speaking, less hairy than most other mammalia. But in this respect nations differ. For, not to mention those nations who to this day carefully pluck out their beard or the hair of other parts, others appear naturally destitute of hair, *v.c.* the Tunguses and Burats. (C) On the contrary, creditable travellers assert that some inhabitants of the islands in the Pacific and Indian Ocean are remarkably hairy.[n] (D)

188. Nor is there less variety in its length, flexibility, colour, and disposition to curl, both in each race of men

[k] Chr. Gottl. Ludwig, *De Humore cutem inungente.* Lips. 1748. 4to.

[l] Lyonet, *Lettre à M. Le Cat.* p. 12.

[m] J. Ph. Withoff, *De pilo Humano.* Duisb. 1750. 4to. Compare the *Commentar. Societ. Scient. Gotting.* vol. ii.

Job. Baster, *Verhandel. der Maatsch. te Haarlem,* t. xiv. p. 382.

C. Asm. Rudolphi, *De pilorum structura.* Gryph. 1806. 4to.

[n] *De Generis Human. Variet. Nativ.* p. 29.

enumerated above (181) and in individuals: *v.c.* the hair of the head in the Caucasian variety is rather dingy or of a nut brown, inclined on the one hand to yellow, and on the other to black; in the Mongolian and American, it is black, stiffer, straight, and more sparing; in the Malay, black, soft, curling, thick, and abundant; in the Ethiopian, black and woolly: In individuals, especially of the Caucasian variety, there are great differences, and chiefly in connection with *temperament*, which is found intimately and invariably connected with the colour, abundance, disposition to curl, &c. of the hair;[p] and there also exists a remarkable correspondence between the colour of the hair and of the irides.

189. The direction of the hairs is peculiar in certain parts, *v. c.*—spiral on the summit of the head;—diverging upwards on the pubes;—on the exterior of the arm, as is commonly seen in some anthropomorphous apes, (*v. c.* in the satyrus and troglodytes) running in two opposite directions towards the elbow, *i. e.* downwards from the shoulder, upwards from the wrist; to say nothing of the eye-lashes and eye-brows.

190. The hairs originate from the inner surface of the corium, which abounds in fat. They adhere to it pretty firmly,[q] by a curious bulb, consisting of a double involucrum;[r]—the exterior vascular and oval, the interior cylindrical, apparently continuous with the epidermis,[s] and sheathing the elastic filaments of which the hair is composed, and which are generally from five to ten in each.

[p] Galen, *Ars Medicinalis*, p. 211—235. M. Ant. Ulm, *Uterus Muliebris*, p. 128. et alibi, and Lavater, *Fragmente*, t. iv. p. 112, among many others.

[q] I suspect that the bulb is intended for support rather than for nourishment, from this circumstance,—that the locks of hairs sometimes found in melicera and steatomata of the omentum and ovarium, some of which I have now before me, are usually destitute of bulbs, because they are not fixed, but lie naked in the honey-like fatty matter.

[r] Duverney, *Œuvres Anatomiques*, vol. i. tab. xvi. fig. 7. 9—14. tab. xvii. fig. 3. sqq.

[s] B. S. Albinus, *Annotat. Academ.* l. vi. tab. iii. fig. 45.

191. The hairs are almost incorruptible, and always anointed by an oily halitus. Of all parts they appear most truly electrical. They are very easily nourished and even reproduced, unless where the skin is diseased. (E)

192. Besides the functions ascribed to the integuments in the former section, must be enumerated their very great excretory power, by which foreign and injurious matters are eliminated from the mass of fluids.[t]

This is exemplified in the miasmata of exanthematic diseases, in the smell of the skin after eating garlic, musk, &c. and in sweating and similar phenomena.[u]

193. What is most worthy of our attention, is the transpiration of an aëriform fluid, denominated, after the very acute philosopher who first applied himself professedly to investigate its importance, the *perspirabile Sanctorianum*,[x] and similar to what is expired from the lungs.[y] It likewise is composed of various proportions of carbon,[z] azote, and hydrogen,[a] precipitates lime from solution, and is unfit to support either flame or respiration.

194. The *sweat*, which seldom occurs spontaneously during health and rest unless in a high temperature, appears to be nothing more than the perspirable matter of Sanctorius too much increased in quantity by the excited action of the cutaneous vessels, its hydrogen uniting with the oxygen of the atmosphere, and assuming the liquid form.

[t] Hence the danger of contagion from hairs, as miasmata adhere to them very tenaciously for a great length of time. Vide Cartwright, *Journal of Transactions on the Coast of Labrador,* vol. i. p. 273. vol. ii. p. 424.

[u] G. Wedemeyer, *Historia Pathologica Pilorum,* (honoured with the royal prize.) Gotting. 1812. 4to.

[x] *Ars* Sanctor. Sanctorii *de Statica Medicina aphorismor. sectionibus vii. comprehensa.* Venet. 1634. 16mo.

[y] C. de Milly and Lavoisier, *Mémoires de l'Acad. des Sc. de Paris.* 1777. p. 221. sq. 360. sq.

J. Ingen-Housz, *Expts. upon Vegetables.* Lond. 1779. 8vo. p. 132. sqq.

J. H. Voight. *Versuch einer neuen Theorie des Feuers,* p. 157. sq.

[z] W. Bache, *On the Morbid Effects of Carbonic Acid Gas on Healthy Animals.* Philadel. 1794. 8vo. p. 46.

[a] Abernethy, l. c.

195. Upon the same hydrogen, variously modified by the accession of other elements and constituents, would seem to depend the natural and peculiar odour perceived in the perspiration and sweat of certain nations and individuals.[b] (F)

196. The quantity of matter perspired from the integuments, which, in a well-grown adult, are equal to about fifteen square feet, cannot be accurately estimated, but is probably about two pounds in twenty-four hours.[c] (G)

NOTES.

(A) One of this family exhibited himself a few years ago in Bond Street. He was thirty years of age, and stated himself to belong to the fourth generation of the descendants of a savage who was found in the woods of America, and had the same condition of skin. He informed me that it is transmitted to every male without exception in the male line, but has never appeared in the females or their male offspring: and that the horny warts first show themselves at two months from birth, are constantly growing, though most in summer, and are constantly being shed, but particularly in winter, till the thirty-sixth year, after which they are never shed, but continue to grow, so that in this man's father, who was eighty years of age, and lived in Suffolk when I saw the man, they were of very great length. They are set so close together, that their tops form a tolerably smooth surface, unless they are separated by extending the skin. Nearest those parts in which there are none, they gradually become smaller. Besides the parts mentioned by Blumenbach, the glans penis, I understood, was free from them.

[b] Fr. L. Andr. Koeler, *De Odore per cutem spirante in statu sano ac morboso.* Gotting. 1794. 4to.

[c] The balance employed by Sanctorius to estimate the loss of perspired matter, is described in his *Comm. in* primam *Fen* primi *L. Canon.* Avicennæ. Venet. 1646. 4to. p. 781.

Another, much simpler and better adapted for the purpose, is described by Jo. Andr. Segner, *De Libra, qua sui quisque corporis pondus explorare posset.* Gotting. 1740. 4to.

J. A. Klindworth, an excellent Gottingen instrument-maker and engineer, altered this at my suggestion, and rendered it more convenient and accurate.

(B) Although Dr. Gordon[d] and Mr. Lawrence[e] assert that they have never been able to detach any thing from the cutis of Europeans in the form of a distinct membrane, the rete Malpighianum does exist in Negroes, and the latter gentleman allows that the various complexions of Europeans and the peculiar cream white of the Albino, who has unquestionably no colouring matter in his eyes or skin, show that it exists even in us.

(C) Dr. Wells describes the singular case of a man whose hair fell off throughout his body in about six weeks, without any evident cause or derangement of health, and did not return, except that about two years afterwards, while labouring under a suppurating tumour of the neck that discharged through several small holes, a fine down appeared upon his cheeks and chin, which occasioned him to shave once a week for about three months, when it disappeared. He always looked afterwards as if just shaved, and by wearing a wig would not have been noticed for any peculiar appearance.[f] Dr. Frank saw a similar case.[g] We have an example of bristly hair shed and renewed every autumn, in five sons of the same family.[h]

(D) The reference is to the Kurille and neighbouring islands. But Krusenstern, a late circumnavigator, declares that he observed no particular hairiness of the people in this part of the world, and that former accounts are at least exaggerations.[i] In the island of Anicoa, he indeed met with one child, eight years of age, covered with hair: but such an instance has occurred in Europe. Zacchias, in 1613, saw a tall man at Rome covered with fine, long, straight hair, of a light yellow colour. There was a sister similarly hairy, and the father had been a hairy person, but the mother had not differed from other women. The man married, and, of four children, one girl and one boy were born covered with black hair, looking, says Zacchias, like black kids, and reminding the attendants of the account of Esau's birth: — "The first came out

[d] *System of Anatomy*, vol. i. p. 242.

[e] Rees's *Cyclopædia*, art. Integuments.

[f] *Transactions of a Society for the Improvement of Medical and Surgical Knowledge*, vol. ii. Another case will be found in the *Edinburgh Journal of Medical Science*, 1827.

[g] *De curandis hominum morbis*, t. iv. p. 124.

[h] *Phil. Trans.* vol. v. quoted by Dr. Good.

[i] *Voyage round the World*. Translated from the original German by G. B. Hoppner, vol. ii. p. 78.

red, all over like a hairy garment."[k] In fifteen days the whole of this hair fell off, and, as puberty approached, soft fine hair sprung up all over the body, even over the temples and forehead.[l] Shenckius has collected several similar cases.[m]

(E) The hairs have been represented destitute of life. But they have turned grey in a single night from excessive copulation, and from distress of mind. In illness they often grow soft, and hang about the head. I know a lady whose hair will not keep in curl if she is in the slightest degree indisposed, and a young gentleman whose profuse curly hair becomes straight under the same circumstances: on the other hand, a case is recorded in which it always curled in a fit of the gout.[n] Lastly, the hair has been so sensible in phrenitis after an injury, that the slightest touch gave severe pain, and when the surgeon clipped a hair unseen by the patient, this was instantly felt, and occasioned a paroxysm of rage:[o] sensibility cannot be acquired by a part not already alive.

Hair often grows abundantly in portions of the skin usually not much supplied with it, and these are generally of a brown colour: it will sometimes grow in parts naturally destitute of it, as the tongue and even the heart.[p] Sometimes it grows in encysted tumours accompanied by fat, and occasionally by teeth and portions of jaw and amorphous bone; and feathers covered by fat are sometimes found in the thorax and abdomen of tame geese and ducks.[q] Hair has also been discharged from the urethra.

(F) The odour of the secretions of the mucous follicles differs in different parts. In the tonsils, when the secretion is solid, it is horridly offensive, really fæcal, and is a frequent cause of fœtid breath: in the glands behind the ears, when the secretion is squeezed out in a solid form, its smell is said to be caseous: in the parts of generation, peculiar. In many brutes, the odour of the female genitals attracts the male, and is strongest when the animal is in heat. The mere sweat has a different smell in different parts: in the arm-pits hircine; in the feet, sometimes like that of tan,

[k] *Genesis*, c. xxv.

[l] *Quæstiones Medico-Legales*, lib. vii. Tit. 1. quæst. ix.

[m] Παρατηρήσιων, sive *Observ. &c. Volumen*, p. 778. sq.

[n] *Quarterly Journal of Foreign Medicine*, No. xvii.

[o] l. c. ibid.

[p] See references in Dr. Good's *Study of Medicine*, vol. v. p. 681.

[q] Blumenbach, *Comparative Anatomy*, § 138.

and sometimes of cabbage-water. Persons differ not only in the amount of their general perspiration, but in its amount in different parts ; and under exercise and heat, different persons sweat most in different parts. A person from merely happening to sweat most in a part whose secretion is generally offensive, may probably acquire the characteristic odour, without having a particular disposition to filthiness of secretion. The general perspiration of every one probably smells peculiarly; for savages can distinguish the nation of persons by the smell. (Haller and Humboldt.) The boy born deaf and blind, whose history is related by Mr. Dugald Stewart, distinguished people by their odour; and I saw in the report of a trial lately in the newspapers, that dealers in hair boasted of being able to tell the nation from which the hair came merely by the smell. The power possessed by brutes in distinguishing and tracing other animals is well known.

The odour of some persons is said to have been quite a perfume. In the memoirs of the Queen of Navarre, we read that Catharine de Medicis was a nosegay ; and Cujacius the civilian, and Lord Herbert of Cherbury, were equally delightful.

(G) The skin produces *chemical changes* similar to those which occur in the lungs (171);[r] forms a watery *secretion* (193. sqq.), and is an organ of *absorption*.

[r] Cruikshanks on *Insensible Perspiration*, and Ellis, *Further Enquiry on the Changes produced in Atmospheric Air*, &c. Others have questioned this, but no one doubts the fact in regard to cold-blooded animals. Dr. Edwards found the surface of frogs and salamanders to carbonise the air. (l.c. p.12.) Frogs are amphibious. They live indefinitely in extensive or renewed water, and die if it is de-aërated, or not changed (p. 41. sqq.) ; as also do aquatic salamanders and the common toad. If their lungs are removed, they still live indefinitely in such water or in air, and die if no air has access to their skin, or the water is not purified enough (p. 71.) ; and die sooner as they are younger and smaller. Although frogs live in air, mere respiration appears insufficient after a time ; — some application of air or aërated water to the surface is also requisite to their life. That they live so long inclosed in wood or mineral substances, as is commonly known, appears owing to the opposition afforded, under these circumstances, to transpiration, which, in the open air, is so great as speedily to dry them up, while, at the same time, the closeness is not such as entirely to exclude air (p. 13.) They die in vacuo.

In a limited quantity of water, they die sooner, the higher the temperature (p. 25. sqq.) ; and they support a high temperature better, if previously subjected for some time to a cold temperature (p. 33. sqq.) Although their skin be carefully moistened, they cannot live without respiration in summer (p. 91.) It appears from Dr. Edwards's experiments to be a general fact among animals, To ascertain the quantity of watery *secretion*, Lavoisier and Seguin[s] inclosed the body in a silk bag varnished with elastic gum and having a small opening carefully cemented around the mouth, so that, by weighing the body previously and subsequently to the experiment, they were able to ascertain exactly what had been lost, and, by substracting from this loss the weight of the perspired contents of the bag, they also ascertained how much of this had passed off by the lungs. From repeated trials they found the mean pulmonary discharge in twenty-four hours amounted to 15 oz. and the cutaneous to 30 oz. The quantity of carbon separated by the lungs ought however to be taken into the account. If it amount to 11 oz. in twenty-four hours,—the quantity stated by Allen and Pepys, — there will be but 4 oz. of pulmonary exhalation. But if oxygen and azote are absorbed in respiration, there must have been correspondently more pulmonary exhalation; and we have seen that Hales estimated it at about 20 oz. in the twenty-four hours. They found the cutaneous transpiration at its minimum during and immediately after meals, and at its maximum during digestion.

The minimum after digestion was found by them to be 11 grs. per minute; the maximum 32 grs.: at and immediately after dinner $10\frac{2}{10}$, and the maximum $19\frac{1}{10}$, under the most favourable and unfavourable circumstances. It was increased by liquid, but not by solid, food. The pulmonary they regard as greater than the cu-

---

that the want of air is best borne in a low temperature. The general good effect of the application of cold in asphyxia by carbonic acid, is well known. The greater the external heat, on the contrary, the more is air required by the skin and lungs, independently, it would appear, of its chemical effect, as it is of use when there is no circulation, — when the heart is excised, either in frogs or cats, which perish after this operation the sooner as the temperature is higher. When the quantity of water, though limited, is sufficient to support life, the want of respiration causes the frogs to become as slow in their motions as turtles, and dull to all impressions on the senses. (p. 65.) Lizards, serpents, and turtles, also carbonise the air by their surface; but serpents and turtles, and, indeed, some varieties of frogs, can live by respiration only, and this happens where the lungs of the animal are proportionally large (p. 128.) The effect of air, however, upon the surface, in reptiles at least, does not require the aid of circulation to distribute its benefits, for when their heart is removed (and the same happens with toads, salamanders, and cats), they live much longer in air than in de-aërated water (p. 3. sqq.); yet they live longer if the heart is not removed (p. 7. sqq.)

[s] *Mémoires de l'Academie des Sciences*, 1790.

taneous proportionally to the surface on which it occurs.[t] Whatever was taken, the weight was found to become ultimately as before. Indigestion lessened transpiration, and the body continued heavier generally till the fifth day, when the original weight was restored. Transpiration was less in moist air and at a low temperature, and the pulmonary and cutaneous transpirations obeyed the same laws.

Dr. Edwards has made a great number of experiments upon this subject.[u] He distinguishes the loss of fluid by evaporation of what is exuded, from that by secretion.[x] The former occurs even in the dead body, and is increased, in both the dead and living, and among all animals, by the dryness, motion, and diminished pressure of the atmosphere. It may be suspended by saturating the air with moisture, and by employing animals (vertebrated, cold-blooded) whose temperature is not above that of the atmosphere ; for if those are employed whose temperature exceeds that of the atmosphere, the air as soon as it touches them is rarefied, can take up more moisture, and is no longer air saturated with moisture. These circumstances, of course, affect only the removal or evaporation of fluid which may have either transuded or been secreted, but do not affect the secretion. In frogs, which perspire copiously, the loss by evaporation at 68° is thus found six times greater than by mere secretion, and the proportion in man, the temperature being the same and the air dry, must be greater, as his skin secretes much less.

The secreted fluid may be carried off by evaporation as quickly as it is formed, so as to be insensible perspiration, or may be too abundant for this, and appear as sweat. The transuded fluid may also be condensed and precipitated on the skin in the form of sweat.

The cutaneous secretion is not so much augmented by moderate elevations of temperature as might be imagined ; but as the elevation proceeds, the augmentation of secretion becomes more than proportionate. It appeared increased after meals and during sleep, and, though subject to great fluctuations if observed at short intervals, from accidental changes in the atmosphere, underwent successive diminutions when observed every six hours, from six o'clock a. m.,—the hour of rising, — till the return of the

[t] *Annales de Chimie,* t. xc. [u] l. c. part iv. c. xi.

[x] He contends, however, that, in the lungs, all is evaporation without secretion. But, with Dr. Bostock, I must dissent from him.

same period. In frogs this regular diminution might be detected every three hours.[y]

In frogs the cutaneous secretion continues, though at its minimum, in the moistest air and in water; and it would appear to do so also in man.[z]

The matter of the cutaneous secretion contains an acid, probably the acetic, a muriate of potash and soda, acetate of soda, and perhaps albumen.[a] What evaporates is mere water.

Dr. Edwards makes some curious remarks upon the different effects of dry and moist air when hot, and when cold. When hot, dry air will of course communicate less heat to the body than if moist, and will, by its dryness, cause more evaporation; so that the two operations of air, dry or moist, will correspond in temperatures above that of the body. When cold, dry air will remove less heat from the body than moist, but, by its dryness, will cause more evaporation, and therefore tend to cool more, so that the two operations oppose each other in temperatures inferior to that of the body.[b] The same remarks apply to cold water.

He did not find moist cold air to cool animals more than dry cold air.

In low temperatures, we have seen that the loss by evaporation greatly exceeds that by secretion. In high, it is the reverse, and, when the body is covered with sweat, there can be no loss by the evaporation which occurs, independent of secreted fluid, whether the air be dry or moist. Vapour will cause more loss by secretion than dry air; but no loss can take place by the lungs in hot vapour.[c]

Perspiration can never be entirely suppressed, because the cold which suppresses secretion, causes the air, however moist, and therefore opposed to evaporation, to rise in temperature, by coming in contact with the body; and the superior temperature, which it instantly acquires, enables it to hold more moisture, and evaporation from the skin is thus instantly promoted.[d]

Absorption by the skin, unless friction is employed or the cuticle abraded, has been denied. We are told that Dr. Currie's patient, labouring under dysphagia seated in the œsophagus,

[y] For what relates to this function in the batracians, see l. c. part i. c. v. and vi.

[z] p. 92. sqq. 98. sqq. 351. sqq.

[a] Berzelius, *Animal Chemistry*, p. 95.

[b] l. c. p. 386. sq.

[c] p. 380. sq.

[d] p. 335. sq.

always found his thirst relieved by bathing, but never acquired the least additional weight:[e] that Dr. Gerard's diabetic patient weighed no more after cold or warm bathing than previously:[f] that Seguin found no mercurial effects from bathing a person in a mercurial solution, provided the cuticle remained entire; while they occurred when the cuticle was abraded.[g]

But the two former cases are no proofs that water was not absorbed, because the persons immersed did not lose in weight, which they would have done if not immersed, owing to the pulmonary and cutaneous excretions; these therefore must have been counterbalanced by absorption somewhere, and no shadow of proof can be urged against its occurrence by the skin, as Dr. Kellie remarks in his excellent paper on the functions of this part.[h] Seguin besides found two grains of the mercurial salt disappear in an hour from the solution when of the temperature of 72½°.

There is every reason to believe the occurrence of cutaneous absorption independently of friction or abrasion of the cuticle. First, the existence of absorbents all over the surface cannot be intended for use merely when friction is employed or the cuticle abraded. Secondly, we have many facts which prove absorption without these circumstances, either by the skin or lungs, or both, while no reason can be given why they should be attributed solely to the lungs. A boy at Newmarket, who had been greatly reduced before a race, was found to have gained 30 oz. in weight during an hour, in which time he had only half a glass of wine.[i] Dr. Home, after being fatigued and going to bed supperless, gained 2 oz. in weight before seven in the morning.[i] In three diabetic patients of Dr. Bardsley's, the amount of the urine exceeded that of the ingesta, and the body even increased in weight, and in one of the instances as much as 17 lbs.[k] Dr. Currie allows that in his patient, "The egesta exceeded the ingesta in a proportion much greater than the waste of his body will explain, and, indeed, such facts occur every day." The same patient's urine, too, after the daily use of the bath, flowed more abundantly and became less pungent. Keill says that he one night gained 18 oz. in his sleep: and Lining, that after drinking some punch one cool day, "the quantity of humid particles attracted by his skin exceeded

[e] *Medical Reports*, &c.
[f] Rollo, *On Diabetes*.
[g] *La Médecine éclairée*, &c. t. 3.
[h] *Edinburgh Med. and Surg. Journal*, vol. i.
[i] Bishop Watson, *Chemical Essays*, vol. iii. p. 101.
[k] *Medical Facts and Experiments*.

the quantity perspired in these two hours and a half by $8\frac{1}{3}$ oz." and gives two more such instances in the same table.[l] Dr. Edwards observed similar facts in guinea-pigs.[m] Thirdly, we have positive evidence of cutaneous absorption without friction or abrasion, in the case of frogs, toads, nay, in scaly lizards, which will increase in weight by cutaneous absorption, even if only a part of them is immersed in water; and remarkably so if previously made to lose much of their moisture by exposûre to the air,[n] although they never surpass the point from which the loss of weight began.[o] The increase is much greater in water than in the moistest air.[p]

In all the cases which have been mentioned there is no reason to suppose that exhalation did not continue, both on the skin and in the lungs, so that the absorption must have been greater than it at first sight appears. When no increase of weight has taken place on immersion in the warm bath, absorption must have occurred to maintain the weight notwithstanding the cutaneous and pulmonary losses; and when some decrease of weight has been observed, we are not justified in concluding that absorption had not taken place, and not lessened the amount of the loss which would have happened. Indeed, there is no doubt that perspiration is considerably increased in the warm bath. — I may remark, that while absorption is more active accordingly as more fluid has been lost, it gradually becomes less as it approaches the habitual standard of plenitude in the individual, and that while transpiration is increased by elevation, the proportion of absorption is increased by depression, of temperature.[q]

Dr. Massy, of America, about 1812, found that, if the body were immersed in a decoction of madder, this substance became discoverable in the urine by the alkalies, and Dr. Rousseau, in conjunction with Dr. S. B. Smith, made, in consequence, a number of experiments from which they conclude that rhubarb and madder are so absorbed, and that these only of all absorbed substances can be discovered in the urine, and are seen in that fluid only, and are absorbed by no other parts than the spaces between the middle of the thigh and hip, and between the middle of the arm and shoulder.[r]

[l] *Phil. Trans.* vol. xlii. p. 496. [m] l. c. p. 362.

[n] Dr. Edwards, l. c. part iv. ch. xii.

[o] l c. p. 101. [p] l. c. p. 360.

[q] l. c. p. 98. sqq. 352. sqq.

[r] *Discourses on the Elements of Therapeutics and Mat. Med.* 1817. p. 56. sq.

SECT. XII.

OF THE FUNCTIONS OF THE NERVOUS SYSTEM IN GENERAL.

197. We now come to the other class of functions termed *animal* (83, II.), by which the body and mind are connected. They have obtained their name from existing in animal systems only, and from enjoying a greater range than those properly denominated vital.[a]

198. The principal organs of these functions are the brain and medulla spinalis, together with the nerves, the greater part of which originate from the two former. They may be properly referred to two principal classes, *sensorial* and *nervous:* the former comprehending all excepting the nerves and their immediate origin, — all that serves more directly as the connection between the office of the nerves and the faculties of the mind.

199. Upon this division rests the beautiful observation of Sömmerring[b] respecting the correspondence between the relative size of each class with the faculties of the mind, — That the smaller the nerves are, compared with the sensorial class, the greater is the development of the mental faculties, and that, in this sense, man has the largest brain of all animated beings, — if its bulk be compared with that of the nerves arising from it; but by no means, if its weight be compared with that of the whole body.

[a] In this section consult especially the work of the celebrated Wedemeyer, already referred to, p. 115. note z.

[b] *Diss. de basi encephali.* Gotting. 1778. 4to. p. 17. Also his work, already quoted, upon the anatomy of the negro, i. 59. sq.

J. Gottfr. Ebel, *Observationes neurologicæ ex anatome comparata.* Traj. ad Viadr. 1788. 8vo.

200. Besides the bony cranium, a threefold covering is afforded to the brain,[c] viz. the dura and pia mater, and, between these two, the tunica arachnoidea.

201. The *dura mater*,[d] which lines the inside of the cranium, like a periosteum, forms various processes. By the falx it divides the hemispheres of the cerebrum and cerebellum; (A) by the tentorium[e] it supports the posterior lobes of the cerebrum, and prevents their pressure upon the subjacent cerebellum.

In its various duplicatures it contains and supports the venous sinuses[f] and prevents their pressure. These receive the blood returning from the brain to the heart, the proportion of which to the blood of the rest of the body, Zinn, who was formerly one of our number, long ago very truly remarked, has been overrated by physiologists.

202. Next to the dura mater lies the *arachnoid*, so named from its thinness. Its use is not exactly known; it is destitute of blood-vessels (5), and extended, like the dura mater,

[c] Eustachius, tab. xvii, xviii.

Haller, *Icones Anat.* fasc. vi. tab. i, ii, iii.

Santorini, tab. posth. ii, iii.

F. B. Osiander, in the *Comment. Soc. Reg. Scient. Gotting.* vol. xvi. p. 105. tab. i, ii.

Detm. W. Soemmerring, *De oculor. sect. horizontali*, tab. i. Others will be mentioned hereafter.

[d] J. Ladmiral, *Icones duræ matris in concava et convexa superficie visæ.* Amst. 1738. fasc. i, ii. 4to.

[e] In the skulls of some genera of mammalia, a remarkable lamina of bone penetrates a duplicature of the tentorium and supports it. Cheselden (*Anat. of the Bones*, c. 8.) supposes this bony tentorium to exist in *feræ* only; but it is found in the equine genus, the cercopithecus paniscus, the delphinus phocæna, orycteropous capensis, &c. Its use is uncertain: that which is generally ascribed to it (for instance, by Laur. Nihell, *de cerebro.* Edin. 1780. p. 4.), — of protecting the cerebellum in those mammalia which leap very swiftly, is improbable, because we find it in the bear and other animals of still slower motion, and not in the ibex, which moves with the greatest rapidity.

[f] Vieussens, *Neurograph. universal.* tab. xvii. fig. 1.

Duverney, *Œuvres anatom.* vol. i. tab. iv.

Haller, *Icones Anat.* fasc. i. tab. vi.

Walter, *De morbis peritonæi et apoplexia.* Berol. 1785. 4to. tab. iii, iv.

Vicq. d'Azyr, *Planches Anatomiques*, xxxii. et xxxv.

merely over the substance of the brain, without following the course of its furrows and prominences.

203. On the contrary, the membrane, called *pia mater* by the ancients, closely follows the cortical substance of the brain,[g] and possesses innumerable blood-vessels which penetrate into the latter. Hence, if a portion of this membrane is detached, we find the external surface very smooth, while the internal is villous and resembles the roots of moss.[h] (B)

204. The brain is composed of various parts which differ in texture and figure,[i] but the use of which is unknown. The most remarkable are the four ventricles,[k] in the two anterior and fourth of which are found the choroid plexuses, of whose function also we are ignorant.[l]

205. The substance of the brain is twofold: the one called cineritious or cortical, though not always situated exteriorly; the other white or medullary. Between the two, the celebrated Sömmerring[m] has detected a third substance of a whitish colour, most conspicuous in the arbor vitæ of the cerebellum and in the posterior lobes of the cerebrum.

206. The proportion of the cineritious[n] to the medullary substance decreases as age advances, being greater in children,

[g] Ruysch, *Respons. ad ep. problemat. nonam.* Amst. 1670. tab. x.

[h] B. S. Albinus, *Annot. Acad.* l. i. tab. ii. fig. 1—5.

[i] Consult, besides other authors already mentioned or to be mentioned hereafter, Jos. and C. Wenzel, *De structura cerebri.* Tubing. 1812. fol.

C. G. Carus, *Darstell. des Nervensystems,* &c. Leipz. 1814. 4to.

C. Fr. Burdach, *Von Bau u. Leben des Gehirns,* vol. i. Leipz. 1819. 4to.

Specially on the successive formation of the fœtal brain, Ign. Döllinger, *Beytr. zur Entwickelungsgesch. des menschl. Gehirns.* Francfort. 1814. fol.

J. L. Schoenlein, *v. der Hirnmetamorph.* 1816. 8vo.

Fr. Tiedemann, *Anat. u. Bildungsgesch. des Gehirns im Fœtus,* &c. Nuremberg. 1816. 4to.

[k] S. Th. Sömmerring, *über das Organ der Seele.* Königsberg. 1796. 4to. tab. i, ii.

[l] The importance of these plexuses is shown in the dissection of maniacs, in whom they alone are very frequently found diseased.

[m] *De basi encephali,* p. 63.

Compare Gennari, *De peculiari structura cerebri.* Parmæ, 1782. 8vo. tab. ii, iii.

[n] Malpighi, *De cerebri cortice;* and his other *Exercitationes de viscerum structura.* Lond. 1699. 12mo.

Ruysch, *De cerebri corticali substantia ep. problemat.* xiima. Amst. 1699. 4to.

Chr. Fred. Ludwig, *De cinerea cerebri substantia.* Lips. 1799. 4to.

less in adults. It is almost wholly composed of an immense number of very fine vessels, both sanguiferous[o] and colourless (92), some few of which penetrate into the medullary substance,[p] composed, in addition to these vessels and a very fine cellular substance, of a pultaceous parenchyma, which, if examined with glasses, exhibits no regular structure,[q] and, upon chemical analysis, affords a peculiar matter, in some measure resembling albumen (C), and containing a large quantity of carbon.[r]

207. The brain, after birth, undergoes a constant and gentle motion,[s] correspondent with respiration; so that, when the lungs shrink in expiration, it rises a little, but, when the chest expands, again subsides.[t]

[o] Sömmerring, *De habitu vasorum cerebri* in *Denkschriften der Acad. der Wiss. zu München,* 1808. tab. i.

[p] B. S. Albinus, *Annat. Acad.* l. i. tab. ii. fig. 4, 5.

[q] Consult Metzger, *Animadversiones ad doctrinam nervorum.* Regiomont. 1783. 4to.

[r] C. Chr. Sass, *De proportionibus quatuor elementorum in Cerebro et Musculis.* Kil. 1818. 4to.

[s] T. Dan. Schlichting first accurately described this striking phenomenon, *Commerc. litter. Noric.* 1744. p. 409. sq., and more largely, *Mém. présentées à l'Acad. des Sc. de Paris,* t. i. p. 113.

Haller sagaciously discovered the cause of it by numerous dissections of living animals. J. Dit. Walstorf, his pupil, *Experimenta circa motum cerebri, cerebelli,* &c. Gotting. 1753.

Consult also, after F. de la Mure's works, Lorry's dissertations on the same point, *Mém. présentées,* t. iii. p. 277. sq. 344. sq.

Also Portal on a similar motion observable in the spinal marrow, *Mém. sur la Nature de plusieurs Maladies,* t. ii. p. 81.

[t] I once enjoyed an opportunity of very distinctly observing this motion, and making some experiments with respect to it, in a young man eighteen years old. Five years before, he had fallen from an eminence and fractured the frontal bone on the left side of the coronal suture, since which time there had been an immense hiatus, covered by merely a soft cicatrix and the common integuments. The hiatus formed a hollow, very deep during sleep, less so when he was awake; and varying according to the state of respiration, *i. e.* very deep if he retained his breath, much more shallow, and even converted into a swelling, by a long-continued expiration. At the bottom of the hollow, I observed a pulsation synchronous with the pulsation of the arterial system, such as deceived Petrioli, Vandelli, and others, at one time the adversaries of Haller, who all foolishly confounded it with that other remarkable motion which depends upon respiration. — I may add, that this wound on the *left* side of the head had rendered the *right* arm and leg paralytic.

208. The *spinal* marrow is continuous with the brain,[u] and may be said either to spring from the brain, as from a root, or, on the contrary, to terminate in it and grow into its substance.[x] Contained in the flexible canal of the vertebræ, it is enveloped by the same membranes as the brain: its substance is also twofold, but the medullary is exterior to the cineritious.

209. From these two sources — the brain and spinal marrow, arises the greater part of those cords, which are more or less white and soft, chiefly composed of fine cellular canals containing nervous medulla,[y] and distributed throughout nearly all the soft parts; some *nerves*,[z] however, may be more properly considered as uniting with the brain and spinal marrow than springing from them. (D)

210. After the numerous experiments[a] of Haller and other very careful observers, we are certain, from minute anatomical examination, that many of the similar parts do

[u] J. J. Huber, *De medulla spinali.* Gotting. 1741. 4to. The plate is also to be found among Haller's fascic. i. tab. ii.

Haller's own plates of the same part are in the same fasciculus, vii. tab. iv, v.

Monro, *On the Nervous System,* tab. x. fig. 1.

G. G. Th. Keuffel, *De medulla spinali.* Hal. 1810. 8vo.

[x] Consult the *Anatomie et Physiologie du Système Nerveux,* &c., par F. J. Gall et G. Spurzheim, t. i. Paris, from 1810. 4to.

[y] Reil, *De structura nervorum.* Hal. 1796. fol.

F. B. Osiander, *Comm. Soc. Reg. Sc. Gotting.* t. xvi.

[z] Rol. Martin's oration *De Proprietatibus Nervorum generalioribus,* prefixed to his *Instit. Neurologicæ.*

[a] See Haller on the sensible parts of the human body, *Comment. Soc. Sc. Gotting.* t. i.

And his three discourses upon them, *Nov. Comment.* t. iii.

Peter Castell, *Experim. quibus constitit varias h. c. partes sentiendi facultate carere.* Gotting. 1753. 4to.

And three entire collections on the controversies excited by the Gottingen publications throughout Europe.

Sull' insensibilita e irritabilita, dissertazioni transportate da J. G. V. Petrini. Rom. 1755. 4to.

Sulla insensitivita ed irritabilita Halleriana *opuscoli raccolti da* G. B. Fabri. Bologna, 1757—59. 4 vols. 4to.

And that which Haller himself published under the title of *Mémoires sur la Nature Sensible et Irritable des Partiet du Corps Humain.* Lausanne, 1756—59. 4 vols. 12mo.

not exhibit any true vestige of nerves; and, from surgical observations [b] and from dissections of living animals, [c] that they do not evince the least sign of feeling.

Such are the cellular substance, the epidermis and reticulum mucosum, the hairs and nails.

The cartilages, bones, periosteum, and medullary membrane.

The tendons, aponeuroses, and ligaments.

Most extended internal membranes, as the dura mater and arachnoid; the pleura, mediastinum, and pericardium; the peritonæum; also the cornea, &c.

The greater part of the absorbsent system, especially the thoracic duct.

Lastly, the secundines and umbilical chord. (E)

211. The ultimate origin of most nerves from the brain cannot be detected. A question is agitated even at the present day, — whether the nerves of each side arise from the

[b] Amidst the great variety, and even contradiction, of opinion, that, as we shall presently mention, exists with respect to the feeling of tendons and other parts when injured, I have always considered negative arguments of more weight than positive, because nothing is more fallacious than the ideas of patients as to *the seat of internal pains.* To say nothing of cases in which amputated parts appear to the patient as still in possession of feeling, it is well known that some have felt a fixed pain for a great length of time in parts where after death no morbid appearance was observable; and that, on the other hand, in chronic diseases, pain is sometimes not felt in the diseased part, but in another which is healthy and perhaps very remote.

We may in this way much more easily explain, for instance, syphilitic pains referred to the bones, than the result of so many contradictory experiments, in which I have seen the medulla of the human subject roughly handled without causing the least uneasiness, though the patient knew what was doing.

[c] I am every day more convinced that much caution, and practice, and repetition of the same experiment in many different kinds of animals, are necessary in establishing the laws of physiology from dissections of living animals. To adduce the example of the supposed feeling of the medulla, I have found different results in many mammalia and birds. Many allowed the medulla to be destroyed without evincing any symptom of pain; others were convulsed, and cried out on the approach of the instrument. The latter might be agitated from the dread of fresh torment, on seeing the knife; and the former, having suffered great torture, might have been insensible to the less violent irritation of the medulla, even although it be endowed with nerves.

corresponding or the opposite portion of the brain.[d] The latter opinion is countenanced by certain pathological phenomena,[e] and by the decussation of fibres in the medulla oblongata[f] and conjunction of the optic nerves.[g] (F)

212. A continuation of the pia mater follows the medulla of the nerves in their course,[h] thus affording it a very delicate vascular cortex.[i] But, as soon as they have quitted the brain or medulla spinalis, their structure becomes peculiar, different from that of all the other similar parts. They form small transverse folds more or less obliquely angular, long since described by P. P. Mollinelli,[k] who not inaptly compared them to the rugæ of earth-worms or the rings of the aspera arteria.

213. The nerves of particular classes, especially the intercostals or great sympathetics,[l] are every where furnished with *ganglia*, or nodules of a compact structure and reddish ash colour, but with whose functions we are scarcely acquainted.[m] I am inclined to believe with Zinn,[n] that they

[d] Lassus has diligently collected the different opinions of writers on this point, *Sur les découvertes faites en Anatomie*, p. 299. sq.

[e] Compare Mein. Sim. Du Pui, *De homine dextro et sinistro*. LB. 1780. 8vo. p. 107. sq.

C. Fr. Ed. Mehlis, *Commentatio* (honoured with the royal prize) *de morbis hominis dextri et sinistri*. Gotting. 1814. 4to.

[f] v. Gall and Spurzheim, and likewise Osiander. ll. cc.

[g] Sömmerring, *Hessischen Beyträgen zur Gelehrsamkeit*. P. i. and iv.

F. N. Nöthig, (præs. Sömmerring) *De decussatione nervorum optic*. Mogunt. 1786. 8vo.

J. F. Ackermann in the *Biblioth. Medica* which I published, vol. iii. p. 337. 706.

Flor. Caldani, *Opuscula Anatomica*. Patav. 1803. 4to. p. 111.

Jos. and C. Wenzel, l. c.

[h] Consult Pfeffinger, *De structura Nervorum*. Argent. 1782. 4to.

[i] Wm. Battie, *De Principiis Animalibus*, p. 126.

[k] *Comment. Instituti Bononiens*. t. iii. 1755. p. 282. sq. fig. 1, 2.

The observation of Mollinelli has been abundantly confirmed and further illustrated by Felix Fontana and Al. Monro: by the latter in his work so often quoted, and by the former in his treatise *Sur le Vénin de la Vipère*. Flor. 1781. 4to. vol. ii.

[l] C. Asm. Rudolphi, *Abhandl. der Berliner Acad. der Wissensch*. 1814. p. 168.

[m] J. Stieglitz, *über den thierischen Magnetismus*. Hanov. 1814. 8vo. p. 536. sq.

[n] *Mém. de l'Acad. des Sc. de Berlin*, vol. ix. 1753.

more intimately unite the nervous filaments which meet in them from various directions, so that each fibre passing out is composed of a portion of every fibre which has entered in.[o] (G)

Nearly the same may, perhaps, be said of the plexuses, which are produced by similar unions and reticulated anastomoses of different nerves, and by a similar contexture of filaments into which the nerves are split.

214. The ganglia and plexuses are most abundantly bestowed upon the spinal nerves and the intercostal or sympathetic nerve. The latter, united by a few delicate filaments only with the rest of the nervous system, constitutes a peculiar system, chiefly belonging to the involuntary functions. For this reason, Bichat, viewing it as presiding over ORGANIC life, distinguished it from the other nerves belonging to ANIMAL life, properly so called, to use his own language.[p]

215. The terminations of the nerves are no less concealed from us than their origins. Excepting a few which spread out in the form of medullary membranes, as the optic nerve which becomes the retina, and the portio mollis of the seventh pair which forms a zone in the spiral laminæ of the cochlea, the ultimate filaments of the rest, penetrating into the viscera, muscles, corium, &c., are so intimately blended with the substance of these parts as, at length, to elude observation.

216. The parts just described, viz. the sensorium, and the nerves originating from it, and distributed throughout the body, constitute that system which, during life, is the bond of union between the body and the mind.

217. That the mind is closely connected with the brain, as the material condition of mental phenomena, is demonstrated, to omit such arguments as the immediate connection between

[o] Consult, among others who treat professedly of the ganglia, Ant. Scarpa, *Anatom. Annotat.* l. i. *de nervor. Gangliis et Plexubus.* Mutin. 1799. 4to.

G. Prochaska, *De structura nervorum.* Vindob. 1780. 8vo.

C. W. Wutzer, *De corporis humani gangliorum fabrica atque usu.* Berol. 1817. 4to.

[p] See Reil, *Archiv. für die Physiologie,* t. vii. p. 189.

the brain and the organs of sense, by our consciousness and by the mental disturbances which ensue upon affections of the brain. (H)

218. The peculiar situation and form, before alluded to, of certain parts of the brain, and likewise some pathological phenomena, have induced various physiologists to suppose certain parts, in particular, the seat of the soul. Some have fixed upon the pineal gland,[q] others the corpus callosum,[r] the pons Varolii, the medulla oblongata, the corpora striata, and the water of the ventricles that washes against the origin of some nerves. Others, not contented with one spot, have assigned particular parts of the brain for individual faculties and propensities. (I)

219. The energy of the whole nervous system does not depend solely upon the brain. The spinal marrow, and even the nerves, are possessed of their own powers, which are sufficient to produce contractions in the muscles. These powers are probably supported by the vascular cortex of those parts (212). In man, the powers proper to the nerves are less, and those dependent upon the brain greater, than in brutes, especially the cold-blooded.

220. The importance of the nervous system to nearly all the functions of the animal economy,—the motion of the heart,[s] respiration,[t] animal heat, (169) digestion, nutrition,[u] and

[q] The Cartesian hypothesis appeared to receive some weight from the dissection of maniacs, in whom the pineal gland was found full of calcareous substances. But more careful observation showed, that, after about the twelfth year, it was generally filled with a pearly sand, in the healthiest persons, though very seldom in brutes. See Sömmerring, *De lapillis vel prope vel intra glandulam pinealem sitis, s. de acervulo cerebri.* Mogunt. 1785. 8vo.

[r] The prerogative of this part was ably refuted by Zinn, *Exp. circa corpus callosum, cerebellum, duram meningem, in vivis animalibus instit.* Gott. 1749. 4to.

[s] Le Gallois, *Sur le Principe de la Vie.* Paris, 1812. 8vo.

B. C. Brodie, Ev. Home, A. P. Wilson Philip, and W. Clift, *Phil. Trans.* 1811. sq. and 1814. sq.

G. R. Treviranus, *Verm. Schr.* t. i. p. 99.

[t] Dupuytren, l.c. Ducr. de Blainville, *Propositions sur la Respiration,* &c. Paris, 1808. 4to.

[u] Treviranus, Biol. t.v. p.107.

most others, is evidently great. It is, however, chiefly two-fold, — To excite motion in other parts, especially in the voluntary muscles, of which function we shall hereafter speak at large; — and to convey impressions made upon the organs of sense to the brain, and there to excite perception, or by means of sympathies (56) to give occasion to reaction.

221. Experiment and observation put these functions of the nervous system beyond the reach of controversy. To unfold their nature is difficult indeed. (K)

222. Most opinions on this subject may be divided into two classes. The one regards the action of the nervous system as consisting in an oscillatory motion; the other ascribes it to the motion of a certain fluid, whose nature is a matter of dispute, by some called animal spirits,[w] and supposed to run in vessels, by others conceived to be a matter analogous to fire, to light, to a peculiar ether, to oxygen, to electricity, or to magnetism, &c.

223. Although I would by no means assent to either of these opinions, I may be allowed to observe that most arguments brought by one party against the hypothesis of the other, must necessarily be rude in proportion to the subtlety, either of the oscillations (if any such exist) of the nerves, or to that of the nervous fluid.

224. These two hypotheses may, perhaps, be united by supposing a nervous fluid thrown into oscillatory vibrations by the action of stimulants.

225. The analogy between the structure of the brain and some secreting organs favours the belief of the existence of a nervous *fluid*.[x] But tubes and canals are evidently no more requisite for its conveyance, than they are requisite in bibulous paper or any other matter employed for filtering.

This opinion receives much weight from the great resemblance of the action of the nerves to the phenomena which

[w] See Michelitz, *Scrutinium Hypotheseos Spirituum Animalium*. Prag. 1782. 8vo.

[x] G. Th. Sömmerring *über den saft, welcher aus den Nerven wieder ausgesaught wird.* Landsh. 1811. 8vo.

are produced by the series of a galvanic apparatus and by the common electric machine,[y] in a living animal or in parts not quite deprived of vitality, and, in fact, long ago induced some physiologists to compare the nervous to the *electric* fluid. The singular and undeniable effects attributed to *animal magnetism*,[z] as well as other phenomena which have given rise to the belief of a kind of sentient atmosphere surrounding the nerves,[a] agree very well with the hypothesis of a peculiar nervous fluid.[b]

226. If we regard the *oscillation* of the nerves, not as similar to that of gross tense chords, but of such a description as may be conceived to occur in the very soft pulp of the brain, we shall find many physiological phenomena exactly corresponding with the supposition.

It is demonstrated that hearing is excited by an oscillation, and why should not this be propagated to the brain?

In vision, also, it very probably occurs, although not to the extent imagined by Leon. Euler.

The penetration of Hartley[c] in following up the conjectures of the great Newton,[d] has rendered it so probable that the action of the other senses is not very dissimilar from this oscillatory motion, that, on the same supposition, he very ingeniously explains, principally by means of the vapour of the ventricles (called by him the denser ether),[e] first, the

[y] Fr. Al. Von Humboldt, *über die gereizte Muskel—und Nervenfaser.* Posen. 1797. vol. ii. 8vo.

J. W. Ritter, *Beweis, dass ein beständiger Galvanismus den Lebensprocess im Thierreiche begleite.* Vinar. 1798. 8vo.

[z] J. Heineken, *Ideen u. Beobachtungen den thierischen Magnetismus betreffend.* Brem. 1800. 8vo.

[a] v. Humboldt and Heineken, ll. cc.

G. C. Berendt, *De atmosphæra nervorum sensitiva.* Gott. 1813. 4to.

[b] Consult, on the other hand, a weighty and acute review of those arguments n Stieglit's work already mentioned, *über den thierischen Magnetismus*, p. 75. sqq. and elsewhere.

[c] Dav. Hartley, *Observat. on Man, his Frame, his Duty, and his Expectations.* Lond. 1749. 8vo. vol. i. p. 44.

[d] *Queries* at the end of his *Optics.* Qu. 23. p. 355. Lond. 1719. 8vo.

[e] Er. Darwin has carried these opinions of Hartley still farther, *Zoonomia,* t. i.

association of ideas, and, again, by the assistance of this, most of the functions of the animal faculties. (L)

NOTES.

(A) Sir Anthony Carlisle, on opening a woman who had died after amputation of a foot, found no falx. The cerebrum was not divided into hemispheres. The edge of the longitudinal sinus was received into a depression, about half an inch deep, that existed along the middle of the superior part of the cerebrum. The head had been unaffected, and the mental faculties perfect, as far as observation was made during the woman's stay in the Westminster Hospital.[f]

I presented to the London Phrenological Society, the cast of the head of a male idiot, aged eighteen years, that was given me by Dr. Formby, of Liverpool, and is only 16 inches in circumference, and 7¾ inches from ear to ear over the vertex. The cerebrum weighed but 1 lb. 7½ oz., and the cerebellum but 4 oz. The hemispheres were united as far back as the vertex, and no falx existed except for about two inches from the anterior part of the tentorium.

(B) The *pia mater* and *tunica arachnoides* were considered as the same, till the Anatomical Society of Amsterdam confirmed, in 1665, the doubts which were arising on the subject, and Van Horne demonstrated both membranes distinctly to his pupils. The *dura mater* corresponds with the fibrous membranes, the *pia mater* with the cellular, and the *tunica arachnoides* with the serous. The latter is, in nature, office, and diseases, exactly like the serous; — a close sac, affording, as the peritonæum does to the abdominal viscera, a double covering to the brain and spinal marrow and the nerves before their departure through the foramina of the *dura mater*, and, according to Bichat, lining the ventricles; insulating the organs on which it lies, and affording them great facility of movement; and liable to all the morbid affections of serous membranes.[g]

[f] *Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge*, vol. i. p. 212. sqq.

[g] Bichat, *Traité des Membranes*.

Between the pia mater and arachnoid of both the brain and spinal marrow, Dr. Magendie has discovered the existence, during life, of a large quantity of clear and colourless fluid, passing from the surface of one organ to that of the other.[h] Cotugno[i] had long ago asserted its existence in the cranial and spinal cavities, after death, and its free communication, and accurately described its qualities; but notwithstanding he gave excellent reasons for believing its existence during life, he imagined the space around the spinal marrow, observed by him to be larger in the emaciated and old, and the space which in these two descriptions of subjects he found also around the brain, to be filled with an aqueous vapour; he also believed its occasional mixture with the fluid of the ventricles. Dr. Magendie has proved the communication, not only of the fluid of the spinal and cerebral cavities but also of the ventricles, by an opening at the point of the calamus scriptorius of the fourth.[k] He conceives it to move from one part to another, as they are severally compressed by sanguineous turgescence during muscular efforts. Bichat had asserted that the arachnoid entered the ventricles by the third, near the venæ Galeni. Dr. Magendie never observed the fluid to escape at this part. If he is correct, I do not understand whether the ventricles are lined by the pia mater or the arachnoid or both. He found the removal of the fluid to occasion immediate dulness and immobility; but that these disappeared as soon as the fluid was replaced, and that its secretion took place very rapidly. He believes that two ounces may exist in the ventricles without disturbance, but that a larger quantity, whether secreted or injected, for example, into the spinal cavity, causes more or less apoplexy and palsy. Much must, however, depend upon the quickness of the accumulation, as the powers of accommodation are very great in living systems.

(C) The medullary substance is evidently fibrous. Mr. Bauer thought he had discovered globules, but then he thinks fibres are series of globules.[l] Dr. Hodgkin has found no globules in either brain or nerves, nor medullary matter in the latter.[m]

[h] *Journal de Physiologie*, t. v.

[i] *Dissertatio de Ischiade Nervosa.* Published in Sandefort's *Thesaurus.*

[k] *Journal de Physiologie,* t. vii. p. 21.

[l] *Phil. Trans.* 1818.

[m] *Philos. Magazine.* August, 1827. See also Magendie's *Précis de Physiologie,* t. i. p. 162.

(D) Dr. Gall has shown that the nerves and spinal marrow do not arise from the brain, but only communicate with it; nor the spinal nerves from the spinal marrow: for, when the brain is absent, the fœtus equally possesses cerebral nerves and spinal marrow, [n] and the brain and spinal marrow, and the brain and cerebral nerves, are in no proportion to each other in the various species of the animal kingdom, nor the spinal nerves to the spinal marrow, nor does the latter diminish as the nerves go off.

The idea of the nerves proceeding from the brain, is as unfounded as that of the arteries proceeding from the heart, or one portion of an extremity from another. Fœtuses are seen with an arterial system, and no hearts; others born with no arms, but fingers at the shoulders. Independently of contrary arguments, we may demand proofs of the opinion: none are given, and it has, no doubt, been derived from the shooting of vegetables.

(E) Although no nerves have yet been discovered in these parts, and although ordinarily they have no feeling, yet that they have, in a lower degree, what, in a higher, is called feeling, is shown by the extreme sensibility which they acquire when inflamed, as they nearly all frequently are, and occasionally without inflammation. Some have sensibility in health to only one kind of irritation. The ligaments may be cut without pain, but if stretched instantly ache. The brain itself will bear great mechanical injury without evincing much pain.

(F) Dr. Gall has also shown, that, besides the numerous communications of the whole nervous system, not only the two sides of the cerebrum, cerebellum, and spinal marrow, are united by commissures, but that the fibres of the anterior pyramidal eminences decussate each other, forming an exception to the rule, observed in every other part of the cranial nervous organs besides the optic nerves and the fibres which run from the genitals to the cerebellum, of the nervous fibres, destined to each side of the body, running on the same side of the brain; and he hence explains why injuries of one side of the brain generally influence the opposite side of the body. The spinal marrow has no decussation.

" We now know, and especially from the modern researches of Drs. Gall and Spurzheim," says Cuvier, " that the *spinal marrow* is a mass of medullary matter, white without, grey within, divided

[n] Gall, *Sur les Fonctions du Cerveau,* t. ii. p. 77. sq.

longitudinally by an anterior and posterior furrow; that its two bands communicate by transverse medullary fibres; that it is enlarged at regular distances, and at each enlargement gives off a pair of nerves; that the medulla oblongata is the superior part of the spinal marrow contained in the cranium, and also gives off several pairs of nerves; that the communicating fibres of its two bands decussate, so that the left go to the right side, and the reverse; that these bands, after having enlarged once by an admixture of grey matter, and having formed the prominence called *pons varolii*, separate, and are termed *crura cerebri*, still continuing to give off nerves; that they enlarge once more by a fresh addition of grey matter to form the masses commonly called *thalami optici*, and a third time to form what have the name of *corpora striata;* that from all the external portion of these latter enlargements arises a layer of greater or less thickness, more or less furrowed externally in different species, completely covered by grey matter which comes above to cover them, forming what are termed the *hemispheres*, and which, after bending down in the middle, unite by one or more commissures, or bands of transverse fibres, the most considerable of which, found only in mammalia, has the title of *corpus callosum*. We also know, that upon the crura cerebri, behind the thalami optici, are one or two pairs of smaller enlargements, known, when there are two pairs of them, as in the mammalia, by the name of *tubercula quadrigemina*, and from the first of which the optic nerves seem to arise; that the olfactory nerve is the only one which does not clearly arise in the medulla or its columns; lastly, that the *cerebellum*, white within, and cineritious without, like the hemispheres, but often much more divided by external furrows, lies transversely behind the tubercula quadrigemina, and upon the medulla oblongata, with which it is united by transverse bands that are styled *crura cerebelli* and inserted into the sides of the pons varolii." [o]

In a word, the fibrous columns of the spinal marrow communicate by intermediate fibres; the fibrous bands of the brain run onwards from the medulla oblongata, diverging and forming the convolutions which may be distended into a great bag, and between both halves of these are converging fibres for connection,

[o] *Report made to the Academy of Sciences upon some Experiments relative to the Nervous System.* Gall, l. c. t.iii. 386. sqq.

called corpus callosum, the anterior commissure, as well as other bands for the same purpose; the pons varolii is the great commissure of the cerebellum, under which the corpora pyramidalia pass to form the anterior and exterior part of the crura cerebri, and afterwards the anterior, inferior, and exterior portion of the anterior and middle lobes (the organs of the intellectual faculties); and the corpora olivaria to form the remaining part of the crura cerebri, and after becoming the thalami optici, and plunging into the corpora striata, to form the posterior lobes, and the superior and more central convolutions (organs of the feelings or affective faculties). Whenever, in the medulla spinalis, or brain, an enlargement occurs in the fibrous bands, there is an accumulation of pulpy matter; improperly termed cortical, because it is sometimes within; and improperly grey, because its colour varies in different animals; but always coexisting with the white or fibrous: from all which circumstances, and its formation before the fibrous, and its great vascularity, Gall supposes it destined for the nourishment of the latter. [p]

I refer to the writings of this physician for a minute account [q] of his great discoveries in the structure of the nervous system, and shall merely bear testimony to the truth of most of his anatomical assertions. Those few which I have not repeatedly seen proved, are I doubt not perfectly accurate. Some of the most candid anatomical lecturers of London have confessed that they knew nothing of the anatomy of the brain till they saw it dissected by his pupil Dr. Spurzheim, and it is a matter of wonder, that, while students are not instructed to dissect limbs and trunks by slices, as we cut brawn, they should be taught no other mode of examining the brain, and thus be left in ignorance of its true structure.

We see Cuvier's admission of many of Gall's discoveries, and, I must add, of discoveries which were doubted or absolutely

[p] See Gall's answer to Tiedemann, who declares the fibrous matter of the spinal marrow to be first formed, after stating that the whole is originally fluid and gradually acquires consistence, and that at length, about the beginning of the fourth month, fibres are seen. l. c. t. vi. p. 65. sqq.

[q] *Anatomie et Physiologie du Systeme nerveux* par F. J. Gall et G. Spurzheim. 4 vols. every line of all which Dr. Gall assured me was written by himself; the two last volumes bear his name only: and *Physiognomical System* and *Anatomy of the Brain*, by Dr. Spurzheim.

denied in a report presented by Cuvier and others to the French Institute, in 1808, — "a report," says Gall, "which will always be one of the most valuable proofs of the backward state of the anatomical and physiological knowledge of the nervous system at that time, and how much science owes me in this respect."[r] "Reil," says Professor Bischoff, "who, as a profound anatomist and judicious physiologist, requires not my praise, rising superior to all the littlenesses of vanity, has declared that he found more in Gall's dissections of the brain than he thought any man could have discovered in his whole life."[s] Loder, after specifying Gall's discoveries, adds, "These discoveries alone would be sufficient to immortalise Gall's name: they are the most important which have been made in anatomy since the discovery of the absorbents." "I am ashamed and indignant with myself for having, with others, been slicing hundreds of brains, like cheese: *I never perceived the forest for the multitude of the trees*."[t]

(G) This opinion is controverted by the argument that the nerves said to enter and leave ganglia are not proportionate; nor the size of ganglia proportionate to the nerves belonging to them.

(H) See Sect. VI. Note (B), and Sect. XLIV. Note (F), near the beginning.

(I) Gall has the immortal honour of having discovered particular parts of the brain to be the seat of different faculties, sentiments, and propensities.

If it is clear that the brain is the organ of mind, it is extremely probable that particular portions of it have different offices.

Numerous old writers had assigned situations for the faculties, but in the most fanciful manner; and, from regarding as distinct faculties what are merely modes of action of faculties to which they were altogether strangers, their assertions on the subject were necessarily groundless and ridiculous. Burton, for example, in his compilation, says, — "*Inner senses* are three in number, so called, because they be within the brainpan, as *common sense*, *phantasie*, and *memory*:" of common sense, "the fore-part of the brain is his *organ* or seat;" of "phantasie or imagination, which some call *æstimative* or *cogi-*

r l.c. t. vi. p. 318.

s Gall, l.c. t.vi. p.490. sqq.

t l.c. t.vi. p.493. In this volume will be found copious answers to Tiedeman, Rudolphi, Serres, &c. and a refutation of many of their anatomical assertions.

tative," "his *organ* is the middle cell of the brain;" and of memory, "his seat and *organ*, the back part of the brain."[u] This was the account of the faculties given by Aristotle, and repeated, with little variation, by the writers of the middle ages. In the 13th century, a head divided into regions according to these opinions was designed by Albert the Great, Bishop of Ratisbon;[x] and another was published by Petrus Montagnana, in 1491.[y] One published at Venice, in 1562, by Ludovico Dolce, a Venetian, in a work upon strengthening and preserving memory, is copied into the *Phrenological Journal*, vol. ii. No. 7. In the British Museum is a chart of the universe and the elements of all sciences, and in which a large head so delineated is conspicuous. It was published at Rome so late as 1632, and, what is singular, engraved at Antwerp by one Theodore Galleus, and the head is really a good family likeness of Dr. Gall, who, however, was born at Tiefenbrun in Suabia, between Stuttgard and the Rhine, March 9. 1757.[z]

It is, however, more than probable that the different parts of the brain have different offices. Its faculties are so various, that it is impossible to imagine them possessed by the same portion. The faculty of melody is perfectly different from the love of offspring. If to suppose all parts of the brain are organs for all faculties is impossible, the difficulty appears greater on reflecting

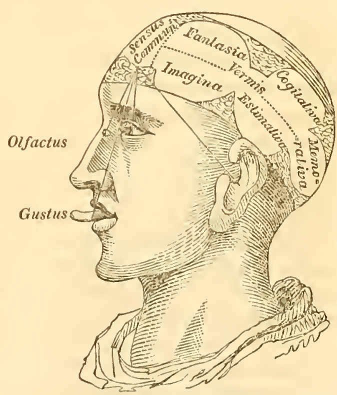
[u] *Anatomy of Melancholy*, P. 1. S. 1. Mem. 2. Subs. 7.

[x] In the *Tesoretto* of Brunetto Latini, the preceptor of Dante, published in that century, the doctrine is taught in rhime:

Nel capo son tre celle,
Ed io dirò di quelle,
Davanti è lo intelletto
E la forza d'apprendere
Quello che puote intendere.
In mezzo è la ragione
E la discrezione
Che scherne buono e male.
E lo terno e l'iguale
Dirietro sta con gloria
La valente memoria,
Che ricorda e retiene
Quello ch' in essa viene.

[y] Gall, l. c. t. ii. p. 354. sq.

[z] *Edinb. Phrenol. Transact.* p. 1.



Head given by Dolce, 1562.

that in that case the whole brain must be concerned in every act and feeling, or, if the whole brain is not thus constantly at work at all things, that different parts must perform the very same offices at different times, each part working in every kind of mental act and feeling in its turn. Neither does the brain perform merely one thing, as the liver secretes merely one fluid, bile ; nor is its structure the same throughout, like that of the liver.

The best authors hold that its various parts have various offices,[a] and Gall *proves* that they have.

If the old course, recommended by Mr. Dugald Stewart, of investigating the mind by attending to the subjects of our own consciousness, had been persevered in, the science of mind would have remained stationary for ever.[b] Who can judge fairly of

[a] "The brain is a very complicated organ," says Bonnet, "or rather an *assemblage of very different organs.*" (*Palingénésie*, t. i. p. 334.) Tissot contends that *every* perception has *different* fibres. (*Œuvres*, t. iii. p. 33.) Cuvier says, that "*certain* parts of the brain in all classes of animals are large or small according to certain qualities of the animals." *Anatomie Comparée*, t. ii. Sömmerring trusts that we shall one day find the *particular seats of the different* orders of *ideas*. "Let the timid, therefore, take courage," says Dr. Georget, in his admirable work upon the nervous system, "and after the example of such high authorities, fear not to commit the unpardonable crime of innovation, of passing for cranioscopists, by admitting the plurality of the faculties and mental organs of the brain, or at least by daring to examine the subject." *De la Physiologie du Système Nerveux et specialement du Cerveau*, t. i. p. 126. Gall's successful reply to some very unjust observations made in this work, will be found in the *Fonct. du Cerveau.* t. v. p. 488. sqq.

[b] Although Professor Dugald Stewart declares, that in his own inquiries he has "aimed at nothing more than to ascertain, in the first place, the laws of our constitution, as far as they can be discovered by attention to the subjects of our own consciousness;" (*Essays*, Preliminary Dissertation, p. 2.) that "the whole of a philosopher's life, if he spends it to any purpose, is one continued series of experiments on his own faculties and powers;" (p. 40.) and that "the structure of the mind (whatever collateral aids may be derived from observing the varieties of genius in our fellow-creatures) is accessible to those only who can retire into the deepest recesses of their own internal frame;" yet he adds, "even to those, presenting, along with the generic attributes of the race, many of the specific peculiarities of the individual," (*Elements*, vol. ii. p. 513.) and has really the following passages in the forty-second and forty-third pages of the *Essays*. — "To counterbalance the disadvantages which this science of mind lies under, in consequence of its slender stock of experiments, made directly and intentionally on the minds of our fellow-creatures, human life exhibits to our observation a boundless variety, both of intellectual and moral phenomena, by a diligent study of which, we may

his own character and talents? Not only is "the *heart* of man deceitful above measure," but we give ourselves credit for *talents* which others know to be insignificant. Our powers, too, and dispositions, are distributed in such various degrees, that, from this single circumstance, every man, judging from himself only, would draw up a different account of the human mind. It is only by extensive observation of others, of different sexes, ages, education, occupations, and habits, that this knowledge is to be acquired. Nor would much progress have been made without the discovery, that strength of individual talent and disposition was associated with proportionate development of particular portions of the brain. By this remark the existence of particular faculties, sentiments, and propensities, was firmly established, and indeed Dr. Gall discovered them by observing persons conspicuous in some mental points to have certain portions of the head extremely large. I did but allude to craniology while detailing Dr. Gall's account of the mind (Sect. V.), because the arrangement may be perfectly accurate, although craniology be false; nor when speaking of the brain as the organ of the mind (Sect. VI.), because that fact also is independent of Dr. Gall's system. But if now the account of the mind, the use of the brain, and craniology, be viewed together, they will all be seen mutually and beautifully to confirm each other.

Much invective, but little argument, has been written against the doctrine. We are presented with a simple statement—that strength of certain parts of the mind, is accompanied by strong development of certain parts of the brain, and, *consequently*, of the skull, except in disease and old age; and vice versa. The truth must be ascertained, not by fancying, quibbling, and abusing, but by observing whether this is the case; and every one has it in his power to make the necessary observations. But those who

---

ascertain almost every point that we could wish to investigate, if we had experiments at our command." "Savage society, and all the different modes of civilization; the different callings of individuals, whether liberal or mechanical; the prejudiced clown, the factitious man of fashion; the varying phases of character, from infancy to old age; the prodigies effected by human art, in all the objects around us, laws, government, commerce, religion; but above all, the records of thought preserved in those volumes which fill our libraries, what are they but experiments, by which nature illustrates, for our instruction, on her own grand scale, the varied range of many intellectual faculties, and the omnipotence of education, in fashioning the mind."

have facts to offer in objection must first be so well acquainted with *craniology* as to be able to judge accurately of the development which they adduce, and have carefully ascertained the character and exact talents of the individual whom they fancy an exception. I had heard of a religious bump, a thievish bump, and a murderous bump, and was as lavish of my ridicule and contempt of Dr. Gall's doctrines as any other ignorant person, till I heard his pupil, Dr. Spurzheim, detail them in the Medico Chirurgical Society. They struck me powerfully. The anatomical facts were demonstrated; the metaphysics were simple and natural; and the truth of craniology was evidently to be ascertained by personal observations only. I commenced observations, and so satisfied was I of its correctness, that, whilst the storm was raging violently, I wrote a defence of Gall's doctrine in the only review that was its friend.[c] Above eleven years have now elapsed, during which I have lived making daily observations, but they all confirm Dr. Gall's statements. I have never seen an exception to the accuracy of his general departments of the organs, nor of the situation of most particular organs. Upon some I have not yet made sufficient observations, and I have no doubt that our views of the functions of many will be much modified and improved. It would be absurd to think the system perfect at present. The wonder is that so much was done by only one individual. The science of cerebral organology is entirely Gall's; nearly so henceforward will metaphysics be regarded; and anatomy must acknowledge him among its greatest benefactors. Those who wish to become acquainted with phrenology I must refer to Gall's octavo work, *Sur les Fonctions du Cerveau*, or his *Anatomie et Physiologie du Système nerveux*. The former work deserves to be read, not only by every medical man, but by every moralist, naturalist, legislator, and metaphysician. It is exceedingly eloquent and full of new and splendid truths and illustrations, and infinitely the best for those who would learn phrenology. However great the merits of the books written by Dr. Spurzheim and my excellent friend Mr. G. Combe,[d] its perspicuity and richness at once declare it the work of the great master himself.

[c] *Annals of Medicine and Surgery*, vol. ii. March 1817.

[d] These must be consulted for the peculiar opinions of the writers,— opinions not admitted by Dr. Gall, nor in every instance by each other. The *System* of Mr. Combe is copious and elegant.

The exact situation of the organs can be learnt from drawings or marked heads only. I shall therefore confine myself to remarking: 1st. That the organs of the faculties or qualities common to man and brutes, are placed in parts of the brain common to man and brutes,—at the inferior-posterior, the posterior-inferior, and inferior-anterior parts of the brain, *v. c.* of the instinct of propagation, the love of offspring, the instinct of self-defence, of appropriating, of stratagem, &c. 2dly. Those which belong to man exclusively, and form the barrier between man and brutes, are placed in parts of the brain not possessed by brutes, *viz.* the anterior-superior and superior of the front; *v. c.* of comparative sagacity, causality, wit, poetic talent, and the disposition to religious feelings. 3dly. The more indispensable a quality, or faculty, the nearer are its organs placed to the base of the brain, or median line. The first and most indispensable,—the instinct of propagation, lies nearest the base; that of the love of offspring follows. The organ of the sense of localities is more indispensable than that of the sense of tones or numbers; accordingly the former is situated nearer the median line than the two latter. 4thly. The organs of fundamental qualities and faculties which mutually assist each other, are placed near to each other, *v. c.* the love of propagation and of offspring, of self-defence and the instinct to destroy life, of tones and numbers. 5thly. The organs of analogous fundamental qualities and faculties are equally placed near each other: *v. c.* the organs of the relations of places, colours, tones, and numbers are placed in the same line, as well as the organs of the superior faculties, and the organs of the inferior propensities.[d]

Although the arrangement of the organs is so beautiful, we must not imagine that Gall mapped out the head at pleasure, according to preconceived notions. He discovered one organ after another, just as it might happen, and often one became known to him situated very remotely from the organ last discovered. The set of organs discovered by him turned out as it is, and a strong argument is thus afforded to the truth of his system.

"I defy," says he, "those who attribute my determination of the fundamental faculties and of the seat of their organs to caprice or arbitrary choice, to possess a tenth part of the talent necessary for the most obscure presentiment of this beautiful arrangement; once discovered, it displays the hand of God,

[d] Gall, l. c. t. iii. p 208. sqq.

whom we cannot cease to adore with wonder increasing as his works become more disclosed to our eyes." [e]

If Gall's is the only satisfactory account of the mental faculties, and to me it certainly appears so, this alone is a proof of the truth of his organology. For such an account could not have resulted from imagination; and observation, unaided by reference to development, never produced much that is satisfactory in metaphysics; and it was in fact derived from studying the organisation.

Gall discovered each organ and its faculty either by meeting with individuals very remarkable for the latter, so that he was led to examine their heads; or by noticing a peculiarity of formation in the head which induced him to ascertain their talents and character. He would never have made his discoveries had he not met with persons remarkable in these respects. Sometimes the relation between the remarkable faculty or quality and the local development was tolerably obvious, but generally he had to make numerous observations before he found himself right. After finding two individuals remarkable in the same point of character, and casting their heads, he has examined the casts daily for months before he could discover the precise spot in which they agreed. The discovery being now made, a good organologist will give judgments upon character which must astonish and incontestably prove the truth of phrenology; but the difficulty of making the discovery when all was utter darkness must have been extreme. The indefatigable industry of Gall for so many years, travelling as he did to most of the prisons, mad-houses and hospitals of the Continent; examining the habits and heads of brutes innumerable for comparison; and engaging persons at salaries to examine points for him, in the way of reading, dissecting, casting, and observing living persons, is astonishing; [f] and the success and importance of his researches will, I am satisfied, ensure him a place among the greatest names of the human race, although, like every other discoverer and benefactor, he has been loaded with ridicule and abuse. Whoever knows him must, so far from finding him a quack, admire the profundity and candour of his conversation and the extent of his attainments, and be delighted with his disinterested kindness, and the gentleness and elegance of his manners.

[e] l. c. t. iii. p. 210. sq.

[f] l. c. t. iii. p. 137. sqq. 206. sq.

The composure with which he hears the ill-treatment of the world is most enviable, and demonstrates a mind conscious of truth and good intention.[g]

[g] "The followers of the different schools of philosophy among the Greeks, accused each other of impiety and perjury. The people, in their turn, detested the philosophers, and accused those who investigated principles, with presumptuously encroaching upon the rights of the deity. The novelty of the opinions of Pythagoras caused his banishment from Athens; those of Anaxagoras threw him into prison; the Abderites treated Democritus as a madman, because he dissected dead bodies to discover the cause of insanity; and Socrates, for demonstrating the unity of God, was condemned to drink hemlock.

"The same scandal has been renewed at all times and in all nations. Many of those who distinguished themselves in the fourteenth century by their knowledge of natural things, were put to death as magicians. Galileo, for proving the earth's motion, was imprisoned at the age of seventy. Those who first maintained the influence of climate upon the intellectual character of nations were suspected of materialism.

"Universally, nature treats new truths and their discoverers, in a singular, but uniform manner. With what indignation and animosity have not the greatest benefits been rejected? For instance, potatoes, Peruvian bark, vaccination, &c. As soon as Varolius made his anatomical discoveries, he was decried by Sylvius as the most infamous and ignorant madman. *Vesanum, litterarum imperitissimum, arrogantissimum, calumniatorem maledicentissimum, rerum omnium ignarissimum, transfugam, impium, ingratum, monstrum ignorantiæ, impietatis exemplar perniciosissimum, quod pestilentiali halitu Europam venenat,* &c. Varolius was reproached with dazzling his auditors by a seductive eloquence, and artificially effecting the prolongation of the optic nerves as far as the thalami. Harvey, for maintaining the circulation of the blood, was treated as a visionary; and depravity went so far as to attempt his ruin with James and Charles the First. When it was no longer possible to shorten the optic nerve, or arrest the course of the blood in its vessels, the honour of these discoveries was all at once given to Hippocrates. The physical truths announced by Linnæus, Buffon, the pious philosopher Bonnet, by George Le Roy, were represented as impieties likely to ruin religion and morality. Even the virtuous and generous Lavater was treated as a fatalist and materialist. Every where do fatalism and materialism, placed before the sanctuary of truth, make the world retire. Every where do those, upon whose judgment the public relies, not merely ascribe to the author of a discovery the absurdities of their own prejudices, but even renounce established truths if contrary to their purposes, and revive ancient errors, if calculated to ruin the man who is in their way.

"This is a faithful picture of what has happened to me. I have, therefore, some reason to be proud of having experienced the same lot as men to whom the world is indebted for so great a mass of knowledge. It seems that nature has subjected all truths to persecution, in order to establish them the more firmly; for he who

Whoever acquires sufficient knowledge of the subject to make observations for himself, will soon find the shape of the skull to be as various as character and countenance, and will have hourly amusement both in remarking the relation between intellectual and moral character, sexual, national, and individual, and cranial form and size, and in tracing the resemblance of children in the latter respect to their parents, as well as in talent and disposition.

Should any one doubt his acquaintance with the real talents and character of those friends whose heads he can select for observation, he has only to study the heads of some celebrated men now living, or the authentic casts of the departed, of whose talents and disposition no one can have the slightest doubt, and he will find the coincidence astonishing and invariable.

If these are facts, all objections on the score of fatalism and materialism, however correct, are unworthy of attention. But in truth, phrenology gives no additional support to such views. A stone is destined not to feel; a fish is destined to swim, and a vulture to be a bird of prey; man is destined to be

---

can snatch one from her, always presents a front of brass to the darts hurled against him, and has always force enough to defend and establish it. History shows us that all the efforts and sophisms which are directed against a truth once drawn from darkness, fall like dust blown by the winds against a rock.

"The instance of Aristotle and Descartes should particularly be quoted, when we wish to display the influence of prejudice upon the good or bad fortune of new doctrines. The opponents of Aristotle burnt his books: afterwards, the books of Ramus, who had written against Aristotle, were burnt, and the opponents of the philosopher of Stagira declared heretics; and it was even forbidden by law to dispute his doctrines, under pain of being sent to the galleys. Now there is no longer any discussion about the philosophy of Aristotle. Descartes was persecuted because he taught the innateness of ideas, and the University of Paris burnt his books. He had written the most sublime thoughts upon the existence of God; Voët, his enemy, accused him of atheism. Afterwards, this same university declares itself in favour of innate ideas; and when Locke and Condillac attacked innate ideas, the cry of materialism and fatalism resounded on all sides.

"Thus, the same opinions have at one time been regarded as dangerous because they were new, and at another as useful because they were ancient. We must, therefore, pity mankind, and conclude that the opinions of cotemporaries as to the truth or error, and dangerous or innocent tendencies of a doctrine, are very suspicious, and that the author of a discovery should be anxious only to ascertain whether he has really discovered a truth or not." l. c. t. i. p. 221. sq.

——— " Not prone
And brute as other creatures, but endued
With sanctity of reason, and to erect
His stature, and upright, with front serene,
Govern the rest, self-knowing." *Parad. Lost.* vii.

The very expression "human nature" implies certain innate faculties and dispositions, generally; the circumstance of peculiar degrees of disposition and talents being hereditary, and of each age having its distinctive character, are quite as favourable as phrenology to the belief of *fatalism*. Each has his own talents and disposition; in some way or other they must be obtained, and if the way is discovered, the case does but remain the same as before.[h] Yet whatever may be our innate propensities and powers, we know how much various circumstances influence the development of faculties and the strength of dispositions, and we feel as if we were free agents: we seem to move our right hand or our left, and to sit still or walk, exactly as we choose, and we possess reason and conscience to guide our conduct. But the more we yield to any inclination, the less are we able to withstand it.

" Reason in man obscured or not obeyed,
Immediately inordinate desires
And upstart passions catch the government
From reason: and to servitude reduce
Man, *till then free.*" *Parad. Lost.* xii.

Yet, notwithstanding this *feeling* of freedom, "all theory is," certainly, as Dr. Johnson said, "against the freedom of the will."[i] The objections on the ground of *materialism* are not more applicable to phrenology than to the doctrine now universally admitted,—that the brain is the organ of the mind; and were answered at p. 66. sqq.

Those who have so little soul as always to ask what is the good of *any* discovery in *nature*, may be told that phrenology is calculated to assist parents in the choice of occupations for their

[h] All know that sexual desires are so connected with the genital organs as generally to commence when these become mature, and be prevented by their removal during childhood; but the world does not, therefore, exculpate ravishers and adulterers. The circumstances are precisely the same with all the cerebral organs of propensity.

[i] "All theory is against the freedom of the will; all experience for it." "We know that we are free, and there's an end on't," said Dr. Johnson in conversation. Boswell's *Life of Johnson*, vol. iii. 294. vol. ii. 74.

Consult Gall on *Free Will and Liberty*, l. c. t. i. p. 266. sqq., especially on *Illusory Liberty.*

children. And it may be of much service in confirming some moral views which good sense indeed ought previously to have suggested. Humility and benevolence are two leading duties. If we detect the signs of intellectual deficiency and vice in our own heads, we may learn to think humbly of ourselves; and being put in possession of true self-knowledge, endeavour to strengthen what is too weak and repress what is too strong. If we detect the signs of great talents and virtues in the heads of others, we may love them the more as superior and highly-favoured beings: whereas if we detect the signs of great virtues and talents in our own heads, we may learn to take no praise to ourselves, but be thankful for the gift; and if we detect the signs of intellectual deficiency and vice in others, we may learn to pity rather than to censure. We may learn not to judge others, nor even our own-selves, but to leave judgment to Him who only knows exactly what natural strength of evil inclination, what weakness of good, and what unhappy external circumstances, each has had to contend with. Not revenge, but example, is the professed object of our legal punishments: — example to the culprit himself and others, or, if the punishment is capital, to others only; and therefore frauds, which, from being very easily committed, may become very detrimental to society, are punished more severely than those which, cæteris paribus, from being difficult of perpetration, can scarcely from their frequency become dangerous. Were moral demerit regarded, the fraud easily committed, would, cæteris paribus, be punished the most lightly. A vicious man must be restrained, as a wild beast,[k] for the good of others, though, for aught we know, his faults may, like the acts of the beast of prey, be chargeable rather on his nature; and while we feel justified in confining, and the culprit is perhaps conscious how richly he deserves his fate, we may pity in our hearts and acknowledge that we ourselves have often been less excusable.

> "Teach me to love and to forgive,
> Exact my own defects to scan,
> What others are to feel, and own myself a man."
>
> Gray, *Ode to Adversity.*

Phrenology, too, may be of the highest use when in criminals there may be suspicion of idiotism or insanity. Idiotism often

[k] A man of determined bad principle may in like manner be shunned by the most benevolent, on account of being odious and dangerous, though they wish him so well as ardently to long for his reformation, and pity his organisation, his education, and the circumstances under which he has been placed.

depends on deficiency of cerebral development, and many idiots have been executed for crimes when it was not exactly proved that they were idiotic enough to be unfit for punishment, but whose cranial development might have settled the point at once. Many persons also have been executed who should have been considered madmen, but were not because the fact of illusion was not made out; yet the extreme preponderance of the development of the organs of the propensities over that of the moral sentiments and intellect, would have proved that they were deserving of coercion rather than punishment. Such does the skull of Bellingham, the murderer of Mr. Percival, prove him to have been.

By phrenology the true mental faculties have principally been discovered.

If phrenology teaches the true nature of man, its importance in medicine, education, jurisprudence, and every thing relating to society and conduct, must be at once apparent.[l]

(K) While the brain is evidently the organ of mind, the nerves united with it, and the spinal marrow, together with its nerves, are as evidently the instruments by which it affects, and is affected by, the other parts of the body, to which these nerves are distributed. By their instrumentality, the brain contracts the voluntary muscles, influences the functions of every other part when under the operation of the different passions, and receives impressions made upon every other part.[m] The consequences of divisions of the nerves or spinal marrow, fully substantiate these points.

If a nerve supplying an organ of sense, as the olfactory, optic, or the portio mollis, is compressed, the organ becomes insensible to odours, light, or sounds. If one supplying muscles only, as the motor oculi, patheticus, abducens, portio dura, or lingualis, the will loses power over such muscles. If the spinal marrow, or nerves conveying both volition from the brain and impressions to the brain, the supplied parts lose both sense and motion.[n] In either this or the preceding

[l] See *Phrenological Journal*, and Mr. Combe's *System*, and *Essay on the Constitution of Man*, passim, as well as Gall and Dr. Spurzheim.

[m] No part of the body but the brain can have sensation. The different parts may be so affected, that, by the intervention of nerves between them and the brain, the latter perceives the impressions made upon them; but the *sensation* is in the brain, although instinctively referred to the spot which is its *source*.

[n] These facts are too frequently proved to be doubted; and, consequently, four cases, in which the spinal marrow is said to have been divided without the effect

case, if the divided surface now unconnected with the brain, is irritated (or if, indeed, the parts are not divided, but irritated by pinching), contractions occur in the muscles supplied by them; and if a sedative is applied the muscles become inert. In these cases, too, if the divided surface connected with the brain is irritated, acute pain is felt, as if in the part on which the nerve originally terminated;[o] and after the removal of a limb, it is common for sensations to be experienced by the patient as if he still possessed his hand or his foot. The nerves which only convey volition, and those of the other four senses than touch, give little or no pain when mechanical stimulus is applied: and these have not, like those which are sensible, a ganglion at a short distance from their origin.[p] When nerves supply both muscles and an organ of sense, they are compound, one portion performing but one function, as Mr. Charles Bell first and Dr. Magendie farther proved by separately dividing the nervous bands proceeding from the anterior and posterior parts of the spinal marrow, before their conjunction, when the division of the former deprived the parts supplied of the influence of volition; and the division of the latter, of sensation.[q] The anterior portion of the spinal marrow is nearly insensible, while the posterior is acutely sensible: the division of the former has the same effect as the division of the anterior nerves; of the latter, as the division of the posterior nerves. The destruction of the centre of the spinal marrow by a wire, impairs

---

of paralysis, must be suspected of error. (See Metzer's *Principes de Médicine légale,* translated, with notes, by Ballard, p. 357. sq.) Another has been quoted from Dr. Magendie's *Journal de Physiologie,* t. iii.; but here the anterior portion of the medulla was continuous (p. 184.), though the posterior was destroyed; and the description is confused.

[o] Thus, after the loss of the glans penis, the extremities of the nerves are sensible to venereal pleasure; and I once had an out-patient at St. Thomas's hospital with gonorrhœa, and only an inch of a remnant of penis.

[p] See Dr. Magendie's *Précis de Physiol.* t. i. p. 166. sq.

[q] *The Exposition of the Natural System of the Nerves.* By Charles Bell. *Journal de Physiologie,* t. ii. Mr. C. Bell also proved, in a similar manner, that the fifth pair, except probably the branch not coming from the ganglion of Meckel, gives sensation to the face, &c., and the portio dura, and probably the branch not coming from Meckel's ganglion, convey volition. See Mr. Mayo also, l. c. p. 24. sq.

The opinion that there are distinct nerves for sensation and for motion, had been entertained since the time of Erasistratus by many writers, from the fact of paralytic limbs being sometimes deprived of sensation only, sometimes of moneither sensation nor motion,[r] nor is pain felt by the experiment. The effects of the division of the spinal marrow are of course more extensive in proportion as the division is made higher up, and if made above the origin of the phrenic nerves, which are the chief agents in causing the contraction of the inspiratory muscles, and consequently above the origin of all the nerves of inspiration, death immediately ensues.[s] Yet, in brutes, after removing the head or dividing the spinal marrow, if any limb is irritated, its muscles are thrown into action: thus Sir Gilbert Blane, whose practical labours have equalled and, in a national point of view, surpassed in utility those of every other physician of St. Thomas's, found, after such operations in kittens a few days old, the hind legs to shrink from the touch of a hot wire applied to the hind paws; and the tail move when irritated, after the division of the marrow below the last lumbar vertebra.[t] More divisions than one do not prevent this effect, and if the whole brain is removed except a portion to which the third pair is attached, and the optic nerve is divided, the iris instantly contracts when the extremity of the optic nerve is pinched.[u] Magendie also remarks, that when the posterior roots of the spinal marrow are irritated, besides signs of extreme pain, the muscles below the part irritated are thrown into action, but only on the same side of the body; facts

---

tion only, or even, in the latter case, becoming more sensible than previously. In Pouteau's *Œuvres Posthumes*, published in 1783. vol. ii. p. 532., it is maintained, but the author remarks that it had long been abandoned by anatomists. He erred in supposing that the nerves of sensation came from the cerebrum, and of volition from the cerebellum.

[r] Magendie, *Journal de Physiol.* t. iii. p. 153. sq. The subject is still rather obscure, for Magendie saw some signs of sensation on irritating the anterior bundles, as well as muscular contraction on irritating the posterior. l. c. t. ii. p. 368. sq. See also Dr. Bellingeri's experiments, in the *Bulletin des Sciences Médicales*. June, 1825.

[s] It is thus that animals are every day killed by pitting; a blow on the back of the neck is sufficient to destroy rabbits. Livy informs us, that at the suggestion of Asdrubal, in the battle in which he was slain, when the Carthaginian forces were routed, and their elephants became unmanageable, the drivers destroyed them in a moment by one blow of a hammer upon a knife fixed between the junction of the head and spine. *Histor.* l. xxvii. c. 49. The division of the phrenic nerve only, does not put a stop to respiration. See *Outlines of Human Physiology*, by H. Mayo, p. 96.

[t] *Select Dissertations on several Subjects of Medical Science.* By Sir Gilbert Blane, Bart. London, 1822. p. 262.

[u] Mr. H. Mayo, l. c. p. 234.

all showing a peculiar relation between the nerves of sensation and motion, that originate at the same portions of the nervous system.[x]

If the medulla oblongata exists, consciousness and volition become evident. Mr. Lawrence saw a child with no more encephalon than a bulb, which was a continuation for about an inch above the foramen occipitale from the medulla spinalis, and to which all the nerves from the fifth to the ninth pair were connected.[y] The child's breathing and temperature were natural; it discharged urine and fæces and took food, and at first moved very briskly, and lived four days. If the cerebrum and cerebellum are removed in a living brute, and the same portion of the medulla oblongata left, the poor thing cries if attempts are made to give it pain, and moves its extremities, even sometimes for two hours.[z] Cold-blooded animals live much longer, and the lower we descend in the scale of brutes the more diffused appear the powers of the nervous system: indeed, in the lowest there is, strictly speaking, no brain nor spinal marrow, but ganglions and nerves, which, no doubt, perform the same functions as far as required in those animals, and are, in fact, brains to them, but of a different form and accommodated to their structure.[a] The higher we ascend, the more parts exist above the medulla oblongata, till, rising from fish and reptiles, through the numerous warm-blooded brutes, all distinguished by the relative magnitude of each cerebral part, according to their several mental characters, and seeing the successive additions of cerebral structure and cerebral mass, and of intelligence, we arrive at man, in whom the successive imposition of cerebral matter has reached its maximum, so that the summit of the nervous system, which corresponds with the forehead and vertex, is much larger in him than in any brute,[b] and his intellect and moral feelings are proportionally greater. According to the

[x] *Journal de Physiologie,* t. iii. p. 154.

[y] *Medico-Chirurgical Trans.* vol. v. p. 166. sqq. Some children so circumstanced have even cried. Gall, l. c. t. vi. p. 231.

[z] *Anatomie du Syst. Nerv.* par MM. Magendie and Desmoulins, p. 560. Dr. Magendie, for whose head the dogs, cats, and rabbits of France would offer a reward, if they knew their own interest, says, "It is droll to see animals skip and jump about of their own accord, after you have taken out all their brains a little before the optic tubercles." And as to "new-born kittens," he says, they "tumble over in all directions, and walk so nimbly, if you cut out their hemispheres, that it is quite astonishing." *Journal de Physiologie,* t. iii. p. 155.

[a] Gall, l.c. t.i. p.25. sqq.

[b] See Gall, l. c. t. ii. p. 153. sqq. 365. sqq., t. vi. p. 298. sqq.

smallness of the anterior-superior and of the superior portions of the brain, will individual mental superiority to the brute creation be small. Idiotism may arise from faultiness of texture, but many congenital cases depend upon deficiency of anterior development; and such idiots, as well as the whole brute creation, may be regarded as examples of various cerebral mutilations, made by nature, illustrating the use of the cerebral parts. Attempts to mutilate artificially are not calculated to afford much information. Animals can generally give no opportunity of observing what mental change has been produced by the removal. For instance, when a writer says that the removal of the cerebellum causes no other effect than sluggishness in the animal, — how does he know that sexual desire is not extinguished? When various portions of brain are removed, how can any inference be drawn, during the short existence of the poor animal, as to the state of its various faculties and inclinations? And when another asserts, that after the removal of the hemispheres and cerebellum we may make observations whether the animal will copulate or not,—how can he ascribe any indisposition that may occur, to the removal, when any circumstances of suffering, wound, confinement, or want of food, will make it very difficult to induce an animal to indulge itself with sexual intercourse?[c] It is, besides, difficult, if not generally impossible, to remove one cerebral organ entirely and alone; other parts of the encephalon, &c. are almost certain to be injured;[d] and if others should not be injured, they may be influenced

[c] See Gall, l. c. t. vi. p. 210. From page 178 to 288. are excellent remarks upon the unsatisfactory nature of such experiments as have been made by Fleurens, Rolando, &c. &c. See also t. iii. p. 379. sqq. The first three quarters of the sixth volume should be read by all who are acquainted with the writings of these experimenters, or of Tiedemann, Rudolphi, Serres, &c., upon the brain.

[d] "Where is the anatomist or physiologist who precisely knows all the origins, the whole extent, all the ramifications, all the connections of an organ? You remove the cerebellum, at the same moment you severely injure the medulla oblongata and spinalis, you injure the tuber annulare, you injure the tubercula quadrigemina, consequently, your results relate not merely to all these parts, but to all those which communicate with them, either directly or indirectly. You think you have insulated the tubercles, but these tubercles have connections with the corpora olivaria, the medulla oblongata, the cerebellum, the sense of vision, and many convolutions; the thalami optici, the corpora striata, are connected below with the crura cerebri, the tuber annulare, the medulla oblongata, the pyramids, and the spinal marrow; above, with all the cerebral membrane, all the convolutions, the non-fibrous, grey substance of their surface, with the dif-

by the irritation of the injury,[e] and the effects arising from the sympathetic affection of such parts; just, for example, as we often see epilepsy from exciting causes in every part of the encephalon, and from exciting causes even in distant organs. Amaurosis is frequently induced by wounds of the supra-orbital nerve; sometimes by wounds of the infra-orbital nerve and of the portio dura.[f] Some parts which have distinct names are only portions of organs, so that injury of several parts may have the same effect; we may have blindness from wounding the optic nerves, the tractus optici, or the corpora quadrigemina. Some parts which have distinct names are compound, so that one immediate and obvious effect of injuring them is not the only consequence which would be observed if the others had an opportunity of becoming apparent,—the medulla oblongata is an instance of this,[g] and the recent discovery that many nerves are two-fold.[h]

---

ferent commissures, as the anterior commissure, the great commissure or corpus callosum; with the fornix, the septum lucidum. Thus there does not exist a cerebral part which we do not know to have numerous connections with other parts. I do not except even the corpora mammilaria, the pineal gland, the infundibulum, &c. The connections yet unknown are unquestionably still more numerous." Gall, l. c. p. 240. sqq.

[e] See Gall, l. c. t. iii. p. 409. sqq., where examples are given.

[f] See many cases in Mr. Wardrop's work, *On the Morbid Anatomy of the Eye*, vol.ii. p.179. sqq. The fact is even mentioned by Hippocrates; and, what is singular, the blindness generally arises from an imperfect division of the nerve, and has been cured by making the division complete. The blindness has sometimes taken place instantly, sometimes come on very gradually.

[g] "The tubercula quadrigemina are a continuation of the bands of the medulla oblongata and medulla spinalis. They are also formed by ganglia, one portion of which gives origin to the fibres of the optic nerve.

In the same manner, the medulla oblongata is in a great measure a continuation of the spinal marrow, besides containing many collections of non-fibrous substances, which, like so many ganglions, are the origins of many nerves of the highest importance, and relating to very different functions.

The tuber annulare is not only composed of the nervous bundles of the two hemispheres of the cerebellum, or of the commissure of the cerebellum, but is also a continuation of several bundles of the medulla oblongata and spinalis, of the anterior and posterior, or inferior and superior, pyramids, and contains a considerable quantity of non-fibrous substance interposed between the transverse and longitudinal bundles, and giving rise to fresh filaments for the crura cerebri, the tubercules," &c. Gall, l. c. t. vi. p. 243. sq.

[h] "You cannot insulate even the nerves of sensation before they are complete. The origin of the nerves of taste is confused with the masses of the origin

Hence the contradictory and strange observations and inferences of most experimenters on the brain of living brutes.[i] The same effects moreover do not occur in the same experiments upon different species of animals. The observation of nature's own mutilations in brutes which have little or no development of parts that are large in others, or in man, is therefore preferable; and next to this comes the observation of morbid changes of different parts, a subject, however, incapable of affording information till the faculties had been ascertained by Gall. (See *supra*, p.71.) Still some results of mutilating the living brain appear generally allowed, and are not at all in contradiction to phrenology. The experiments of Fleurens are allowed by Gall to be very ingenious and sometimes satisfactory;[k] and with respect to injuring the cerebellum, Gall remarks, " if it is true that the lesion of the tu-

---

of many other nerves; the auditory is confused with the nervous and non-fibrous masses of the fourth ventricle; the optic nerves at first with all the mass of the tubercles, with the corpora geniculata and their attachments, with the crura cerebri, with the grey layer situated immediately behind their junction. The olfactory nerves are at first intimately connected with the grey substance placed upon the interior and inferior convolutions of the middle lobes, with the anterior cerebral cavities," &c. l. c. t. vi. p. 245.

[i] Fontana says, that after removing the brain of a turtle, and entirely emptying the cranium, the animal lived six months, and walked as before. M. Rolando attempted the experiment repeatedly, but the animal always died as soon as a cut was made behind the cerebellum.

M. Rolando says, he "made innumerable experiments upon goats, lambs, pigs, deer, dogs, cats, and guinea-pigs, to ascertain the results of lesion of the tubercles, and parts near the optic thalami, but rarely obtained the same results." M. Rolando says, that lesion of the thalami optici causes convulsions; M. Fleurens denies it. (Gall, l. c. t. vi. p.191.) M. Rolando found an unsteadiness like that of intoxication follow the removal of two thirds of the lobes of the cerebrum in a chicken. M. Fleurens declares he must have wounded the cerebellum. M. Fleurens protests that the experiments of M. Rolando are contradictory to each other. (p. 215.) And after finding a chicken walk, fly, and swallow, shake its wings, and clean them with its beak, subsequently to losing the hemispheres of its brain, infers, that these are the residence of the understanding and feelings: the cerebellum, according to him, is destined to balance, to regulate motion; yet birds, after losing these parts, pecked and clawed their enemies, and perched. (p. 266.) M. Rolando considers muscular action to depend upon the cerebellum, yet Magendie found animals perform regular motions after losing

[k] l. c. t. vi. p. 249.

bercles in birds always causes convulsions, it is not less true that the tubercles are destined to vision; and in the same way the cerebellum (connected as it is with the medulla oblongata, &c.) may participate in the vital function of the medulla oblongata and spinalis, may give rise to disturbed motion when injured, and yet have its own particular animal functions."[l] That animals should skip and jump, and eat, after losing their hemispheres, is not surprising, if these parts perform the phrenological functions assigned to them, and are not necessary to motion. The medulla oblongata and other lower parts of the encephalon have, no doubt, much to do with motion as well as the spinal marrow, and accordingly, when the oblongata was pressed in the child mentioned by Mr. Lawrence convulsions occurred; and the same effect ensued on irritating it, in Dr. Gall's experiments and those of Lorry.[m] Pressure, however, of it, is also said by vivisectors to occasion stupor.

Dr. Magendie informs us, that,

1. Deep cuts of the hemispheres do not affect motion in mammalia, reptiles, fish, and many birds, any more than their removal; but the latter is said to occasion a blindness in mammalia and birds, though not in fish or frogs, probably from the arrangement of the cerebral parts being different, so that a similar wound affects different organs.

2. If the *white* matter of both corpora striata is cut, the animal darts forward, and retains the attitude of progression, if prevented. He often found animals perform very regular movements after the removal of the cerebellum; yet he observed, that wounds of it and of the medulla oblongata, gave mammalia and birds a tendency to move backwards, though the same effect does not occur in fish.

3. In a vertical section of the crura of the cerebellum, or of the pons varolii from before backwards, the animal immediately rolls forcibly on the same side, making sometimes sixty revolutions in a minute; and a vertical section of the cerebellum from before backwards through the whole substance of the medullary arch over the fourth ventricle has the same effect, and the motion is the more rapid as the section is nearer to the pons varolii. An animal will continue rolling for eight days. If a section is made on each side, the animal rolls from one side to the other.

[l] l. c. t. vi. p. 385. sq.

[m] l. c. t. iii. p. 392.

4. Notwithstanding the decussation of the anterior pyramids, a division of one or both had no sensible effect, except, perhaps, that of retarding motion a little; and a complete division of one-half of the medulla oblongata neither affects sensibility nor prevents irregular motions, though the power of volition appears lost on the same side.

Similar phenomena occur in disease. Persons labouring under hysteria or chorea sometimes roll violently, or spin round.[n] Persons have been known to feel an impulse to move forwards or backwards.[o] An infinite variety, however, of extraordinary and regular movements also occur.

From these experiments I draw no inference. The considerations already mentioned prevent me from concluding that the parts which are cut are the sole organs concerned in giving origin to the peculiar motions, that their sole purpose is for such motions, or even that peculiar motions depend originally upon them. We can only say, as in the case of amaurosis following an injury of the supra-orbital, or infra-orbital nerve, such effects ensue.

In fœtuses without brain or spinal marrow,[p] the circulation, nutrition, secretion, &c. proceed equally as in others, which, besides spinal marrow, nerves, and ganglia, possess a brain.[q] Vegetables absorb, assimilate, circulate, secrete, and in many instances contract on the application of stimuli, and yet are not known to possess nerves. Muscles, after the division of the nerves which connect them with the brain, contract equally as before, when irritated. In animals liable to torpor, the season of torpidity produces its effects equally upon those muscles whose nerves have been divided, or if the brain, &c. is destroyed. After the removal or destruction of the brain and spinal marrow in animals, the heart still continues to act and the blood to circulate, provided respir-

[n] See *Med. Chir. Trans.* vol. v. p. 1. sqq., also vol. vii. p. 237. sqq.

[o] *Précis de Physiologie.*

[p] See *Hist. de l'Acad. des Sciences,* 1711. p. 26. 586., for an instance of the absence of spinal marrow: brainless fœtuses are not uncommon.

Also, *Phil. Trans.* 1775.

Also, Dr. Philip, *Exp. Inquiry into the Laws of the Vital Functions,* p. 49.

[q] Imperfect fœtuses have been seen, with some organs evolved, though not even nerves could be discovered. See *Phil. Trans.* 1793. See on this subject the excellent remarks of Dr. Marshall, in his works edited by Mr. Sawrey, in 1814, and already quoted at p. 68.

ation is artificially supported.[r] But the involuntary functions are closely connected with the brain and spinal marrow, for the *sudden* destruction of these parts or a certain portion of them, puts a stop to the circulation;[s] the application of stimuli to them excites the action of the heart and, even after its removal, of the capillaries;[t] the passions of the mind do the same; nay, more, the involuntary functions seem, in some experiments, as dependent upon the brain and spinal marrow as they probably are upon the ganglia and gangliac nerves, for the removal of a piece of the par vagum, or the destruction of that part of the brain with which it is connected, or of a considerable portion of the spinal marrow, heavily impairs the functions of the lungs and of the stomach,[u] putting a stop, not to the muscular action of the stomach, or to its circulation, but to the secretion of gastric juice and to digestion, and causing the blood to experience no longer the chemical changes in the lungs, but the air-cells to become filled with frothy mucus, the substance gorged with blood, and the surface marked with dark patches, and causing these changes in the two organs even after death, if the experiment is made as soon as the animal is killed,[x] for after the mental functions have ceased, secretion and capillary circulation continue for a time; and although the division of the spinal marrow, or of its nerves, or compression or disorganisation of these or parts of the brain, prevents voluntary power over the corresponding muscles, without suspending the circulation, &c. in them, and does not impede the functions of the lungs or stomach,

[r] Dr. Whytt, *Essays and Obs. Phys. and Literary*, vol. ii. Edin. 1756.
Experiments, &c., by A. P. Wilson Philip, M.D. and Wm. Clift, *Philos. Trans.* 1815.

Also, *Experimental Inquiry*, by the former. London 1826. 3d edit.

[s] Le Gallois, *Sur le Principe de la Vie;* and Wilson Philip, l. c. Probably by excessive stimulus, as the voluntary muscles are afterwards insensible to stimuli, although, after a mere division of their nerves, they retain their excitability.

[t] Dr. Philip, l. c. He conceives this influence of the brain and spinal marrow to be galvanic, as he prevented the ill effects of the removal of a piece of the par vagum upon the lungs and stomach, by supplying these organs with galvanic influence. p. 210. sqq.

Division of the nerve had no effect if the divided ends lay opposite each other, although distant a quarter of an inch from each other. p. 226. sqq.

[u] Le Gallois, l. c. and many former writers.

[x] A mechanical stimulus, or a substance in its nature stimulating, applied to the brain about the origin of the nerves, excites contractions in the voluntary muscles; a substance in its own nature stimulating, excites the heart and capillaries, when applied to any part of the brain or spinal marrow, but requires to be applied to a considerable portion. Dr. Philip, l. c.

yet circulation, and what are dependent upon it, — nutrition and frequently animal heat, are evidently impaired, though perhaps, in some measure, from the want of muscular action and the stimulus of volition. Sir Everard Home found that by dividing the nerves running to the horn of a buck, the temperature of the horn fell about 6° below that of the other, and as the divided ends proceeded in the course of union, the temperature rose again towards a level.[y] In hemiplegia, the least irritation will often produce inflammation, ulceration, and a rapid slough. Division of the fifth pair of nerves close to the brain causes inflammation of the upper part of the eye, and cloudiness of the upper part of the cornea; and its division at the ganglion Gasseri produces opacity of the cornea and ulceration and destruction of the eye.[z] The indisputable connection which exists between the brain and various parts of the body, and the effect which any injury of them must, therefore, be supposed to have over other parts, together with the fact of children living and eating and preserving their temperature for many days, though born without brains, and the fact of amaurosis and even cataract following wounds of the nerves of the face, render it doubtful how far the above-mentioned circumstances show a *dependence* of the organic or vegetable functions upon the brain and spinal marrow, — more than a connection. But a powerful argument in favour of the dependence of these functions upon the ganglions and ganglionic nerves is, the fact, that the ganglionic system of nerves is formed before the brain and spinal marrow; indeed, the nervous system of the chest and abdomen are fully formed, while the brain appears still a pulpy mass.[a]

These ganglia and nerves would hardly be formed before the brain and spinal marrow but for the sake of the organs which they supply, and the functions of which (with the exception of the genitals) are as perfect at birth as at adult age; while the mind and brain are slowly perfected.

A striking difference is observed in the structure and effect of injuries upon them. Bichat asks, "What anatomist has not been struck with the difference between the cerebral and gangliac nerves? Those of the brain are larger, more numerous, whiter, denser, subject to fewer variations. On the other hand, extreme

[y] *Phil. Trans.* 1826.

[z] *Journal de Physiologie*, t.iv. I have frequently witnessed the experiment. The removal of the deer's horns causes the genitals in like manner to waste; and v. v.; yet this is not thought to show dependence, but merely connection.

[a] Gall, l. c. t. i. p.191.

tenuity, considerable number, especially at the plexuses, a grey colour, remarkable softness, and very frequent varieties, are the characters of the gangliac nerves, if you except those which communicate with the cerebral, and some of those which unite these little nervous centres." [b]

If they are cut, or the ganglia torn, no pain is produced, while similar operations on the cerebral or spinal nerves produce horrid torture. If all the ganglia of the neck are removed, and even the first thoracic, no sensible or immediate derangement of the functions is observable, even in parts to which the filaments united with them may be traced.[c] Bichat long since remarked no disturbance of the heart's motion on attempting to irritate, or on dividing, the cardiac filaments of the sympathetic; nor of the stomach, bladder, &c. by applying violence or stimuli to their nerves. Neither did he succeed with galvanism,[d] but Humboldt and Dr. Fowler say they succeeded with galvanism in the case of the heart.[e]

(L) These oscillations are purely hypothetical. Were their existence proved, we should know nothing more of the real nature of the cerebral functions, for we should have to learn what were the peculiar properties of the nervous system, that enabled it alone of all substances to produce, when oscillating, the phenomena which it exhibits. We might as well attempt to explain the phenomena of motion or of chemical affinity and galvanism by vitality and mind, as the phenomena of vitality and mind by mechanics or chemical affinity and galvanism. They are altogether distinct principles, although there can be no question that the laws of mechanics and of chemical affinity and galvanism are important and indispensable in every living system, in subservience to life and mind. The mind, for aught we know, may stimulate the voluntary muscles by means of galvanism communicated along the nerves, but then the galvanism is not mind, it is merely an instrument employed by the mind.[f]

[b] *Recherches Physiologiques*, p. 72. sq. 1805.
See also Gall, l. c. t. vi. p. 312.
Magendie, *Précis Elément.* t. i. p. 171. sq.

[c] Magendie, l. c. says he has made these experiments repeatedly.

[d] l. c. 334. sqq. 360. sqq.

[e] Dr. Le Gallois, *Expériences sur la Vie.*

[f] The voluntary muscles contract for some time after death, when their nerves are galvanised; the involuntary will not, although for twenty-four hours after death the heart is excited on the contact of a mechanical or chemical irritant, *v. c.* Wilson, *Lectures on the Blood*, &c. p. 139.

SECT. XIII.

OF THE EXTERNAL SENSES IN GENERAL, AND OF TOUCH IN PARTICULAR.

227. The other office of the nerves we found to consist in communicating to the sensorium the impressions made by external objects. This is accomplished by the external senses which are, as it were, the watchmen of the body and informers of the mind.

These alone belong to our present subject. For to regard, with Gorter, the stimulus which inclines us to relieve the intestines, the sensation of hunger, and other internal calls of nature, as so many distinct senses, is unnecessary minuteness, as Haller long since observed.[a]

228. *Touch* merits our first attention, because it is the first to manifest itself after birth, its organ is most extensively spread over the whole surface, and it is affected by many properties of external objects.

229. For we perceive not only some qualities, as heat, hardness, weight, &c. by the touch only, but our knowledge obtained by other senses respecting some qualities is rendered more accurate by the touch; such qualities are figure, distance, &c. (A)

230. It is less fallacious than the rest of the senses, and by culture capable of such perfection as in some measure to supply the deficiency of others, particularly of vision.[b]

231. The skin, whose structure we formerly examined, is

[a] J. De Gorter, *Exercitationes Medicæ,* iv. Amst. 1737. 4to.

[b] Consult Rol. Martin, *Schwed. Abhandl.* vol. xxxix. 1777.
G. Bew, *Memoirs of the Society of Manchester,* vol. i. p. 159.
Ch. Hutton, *Mathematical Dictionary,* vol. i. p. 214.

the general organ of touch.[c] The immediate seat of the sense is the papillæ of the corium, of various forms in different parts, commonly resembling warts,[d] in some places fungous,[e] in others filamentous.[f] The extremities of all the cutaneous nerves terminate in these under the form of pulpy penicilli.

232. The *hands* are the principal organs of touch, properly so called, and regarded as the sense which examines solidity, and their skin has many peculiarities. In the palms and on each side of the joints of the fingers, it is furrowed and free from hairs, to facilitate the closing of the hand: and the extremities of both fingers and toes are ridged internally by very beautiful lines more or less spiral;[g] and are shielded externally by nails.

233. These scutiform *nails*[h] are bestowed upon man and a few other genera of mammalia only (we allude to the quadrumana which excel in the sense of touch),[i] for the purpose of resisting pressure, and thus assisting the action of the fingers, while examining objects.

They are of a horny nature, but on the whole very similar to the epidermis. For under them lies the reticulum, which

[c] F. de Riet, *De Organo Tactus.* LB. 1743. 4to. reprinted in Haller's Anatomical Collection, t. iv.

[d] Dav. Corn. de Courcelles, *Icones Musculor. Capitis.* Tab. i. fig. 2, 3.

[e] B. S. Albinus, *Annotat. Academ.* l. iii. tab. iv. fig. 1, 2.

[f] Ruysch, *Thesaur. Anat.* iii. tab. iv. fig. 1. *Thes.* vii. tab. ii. fig. 5. B. S. Albinus, l. c. L. vi. tab. ii. fig. 3, 4.

[g] Grew, *Phil. Trans.* n. 159.

[h] B. S. Albinus, *Annotat. Acad.* l. ii. tab. vii. fig. 4, 5, 6.

[i] Namely, simiæ, papiones, cercopitheci, and lemures, the apices of whose fingers in their four hands are very soft, and marked, as in the human subject, with spiral lines.

Physiologists have disputed whether the sense of touch is bestowed on any besides man and the *quadrumana.* In determining this controversy, we must recollect what was formerly said (81) concerning the difference of constitution according to mode of life. On one side, I would grant to both parties that the snowy hands of a delicate girl must enjoy a much more exquisite sense of touch than what I called the fingers of brutes. But, on the other, I have frequently seen simiæ and papiones possessing much softer fingers, and using these fingers to explore surfaces much more dexterously, than many barbarous nations and innumerable persons among the lower orders of Europeans, whose hands have been hardened by labour.

in negroes is black;[k] and under this again is found the corium, adhering firmly to the periosteum of the last phalanx. These constituent parts of the nails are striated lengthwise. The posterior edge, which, in the hands, is remarkable for a little lunated appearance, is fixed in a furrow of the skin; and the nails growing constantly from this, are protruded forwards, so as to be perfectly renewed about every six months.

NOTE.

(A) The little analogy there is between our sensations of heat and cold and the other sensations commonly ascribed to the sense of touch, has led many writers to consider that such dissimilar feelings must arise from the sensations of different organs. Dr. Spurzheim[l] says, "It may still be asked whether feeling produces ideas of consistency, of hardness, of softness, of solidity and fluidity, of weight and resistance? I think it does not. For the mind to examine these qualities employs the muscular system, rather than the sense of feeling properly so called." This opinion accords with that of Dr. Brown,[m] who states, "The feeling of resistance," (of which he considers the qualities enumerated above as modifications), "is, I conceive, to be ascribed, not to our organ of touch, but to our muscular frame, to which I have already directed your attention, as forming a distinct organ of sense; the affections of which, particularly as existing in combination with other feelings, and modifying our judgments concerning these (as in the case of distant vision, for example), are not less important than those of our other sensitive organs. The sensations of this class are, indeed, in common circumstances, so obscure as to be scarcely heeded or remembered by us; but there is probably no contraction, even of a single muscle, which is not

[k] B. S. Albinus, *De Habitu et Colore Æthiopum.* fig. 3.

[l] *Phrenology*, p. 247.

[m] *Lectures on the Philosophy of the Human Mind.* 2d edit. 1824. p. 480.

attended with some faint degree of sensation that distinguishes it from the contractions of other muscles, or from other degrees of contraction of the same muscle."

Some recent discoveries of Mr. Charles Bell corroborate the views above stated in every essential particular. In a memoir " On the nervous circle which connects the voluntary muscles with the brain," inserted in the *Philosophical Transactions* for 1826, he proves that every muscle has two nerves of different properties supplied to it, so that between the brain and the muscles there is a circle of nerves, one nerve conveying the influence from the brain to the muscles, the other giving the sense of the condition of the muscles to the brain ; also, that if the circle be broken by the division of the motor nerve, motion ceases, and if it be broken by the division of the other nerve, there is no longer a sense of the condition of the muscle, and, therefore, no regulation of its activity. He shows that the spinal nerves are compounded of filaments possessing these different powers, and that each nerve having several properties or endowments collected within itself, proceeds to its destination without intricacy ; but where nerves of different functions take their origin apart (*viz.* when they are derived from the encephalon), and run a different course, two nerves must unite in the muscles, in order to perfect the relations betwixt the brain and these muscles.

The following passages are quoted in Mr. Bell's own words :

" Why are nerves, whose office is to convey sensation, profusely given to muscles, in addition to those motor nerves which are given to excite their motions ? To solve this question, we must determine whether muscles have any other purpose to serve than merely to contract under the influence of motor nerves. For if they have reflective influence, and if their condition is to be felt or conceived, it will presently appear that the motor nerves are not suitable internuncii betwixt them and the sensorium. I shall first inquire if it be necessary to the governance of the muscular frame, that there be a consciousness of the state or degree of action of the muscles ? That we have a sense of the condition of the muscles appears from this : that we feel the effects of over-exertion or weariness, and are excruciated by spasms, and feel the irksomeness of continued position. We possess a power of weighing in the hand; what is this but estimating the muscular force ? We are sensible of the most minute changes of muscular exertion, by which we know the position of the body and limbs, when there is no other means of knowledge open to us. If a rope-dancer measures his steps by the eye, yet, on the other hand, a blind man can balance his body. In standing, walking, and running, every effort of voluntary power which gives motion to the body is directed by a sense of the condition of the muscles, and without this sense we could not regulate their actions, and a very principal inlet to knowledge would be cut off."

In the preceding quotation Mr. Bell attributes to the muscular feeling the power of preservation of the equilibrium of the body. This opinion was originally advanced by Dr. Wells,[n] the profoundest philosopher who was ever physician to St. Thomas's, in the following words: — "What is there within us to indicate these positions of the body? To me it appears evident, that, since they are occasioned and preserved by combinations of the actions of various voluntary muscles, some feeling must attend every such combination, which suggests, from experience, perhaps, the particular position produced by it. But in almost all the positions of the body, the chief part of our muscular efforts is directed toward sustaining it against the influence of its own gravity. Each position, therefore, in which this takes place, must be attended with a feeling which serves to indicate its relation to the horizontal plane of the earth."

[n] *Essays*, 1818. p. 70.

SECT. XIV.

OF TASTE.

234. We perceive tastes by the tongue, and in some degree by the other neighbouring internal cutaneous parts of the mouth, especially by the soft palate, the fauces, the interior of the cheeks, and lips; by them, however, we taste only what is acrid and very bitter.[a]

235. The chief organ of taste is the *tongue*,[b] agile, obsequious, changeable in form; in its remarkably fleshy nature, not unlike the heart; and endowed with far more irritability than any other voluntary muscle.[c]

236. Its integuments resemble the skin. They are, an epithelium, performing the office of cuticle; the reticulum Malpighianum;[d] and a papillary membrane, but little different from the corium.

237. The integuments of the tongue differ from the skin chiefly in these respects—in the epithelium being moistened, not by the oily fluid of the skin, but by a mucus which proceeds from the foramen cæcum of Meibomius[e] and the rest of the glandular expansion of Morgagni,[f]—and, secondly, in the

[a] Grew, *Anatomy of Plants*, p. 284. sq.

Petr. Luchtmans, *De Saporibus et Gustu*. LB. 1758. 4to. p. 58. sqq.

J. Gottl. Leidenfrost, *De sensu qui in faucibus est, ab eo qui in lingua exercetur, diverso*. Duisb. 1771. 4to.

[b] Sömmerring, *Icones Organorum Humanorum Gustus*. Francof. 1808. fol.

[c] This fact, contrary to the opinion of others, I have proved by dissection of living animals, and by pathological observation. *Specimen historiæ naturalis ex auctoribus classicis illustratæ*. Gotting. 1816. 4to. p. 4. sqq.

[d] In dogs and sheep with variegated skin, I have commonly found the reticulum of the tongue and fauces also variegated.

[e] Consult Just. Schrader, *Observat. et Histor.* from Harvey's book *De Generatione Animalium*. p. 186.

[f] Morgagni, *Adversar. Anat. Prima*. Tab. 1.

conformation of the papillæ, which are commonly divided into petiolated, obtuse, and conical.[g] The first are in very small number and situated in a lunated series at the root of the tongue; the others, of various magnitudes, lie promiscuously upon the back of the tongue, and chiefly upon its edges and apex, where taste is most acute.[h]

238. These papillæ are furnished with extreme filaments of the lingual branch of the fifth pair;[i] and through them, probably, we acquire the power of tasting.

The ninth pair,[k] and the branch of the eighth which also supplies the tongue,[l] appear intended rather for the various movements of the organ, in manducation, deglutition, speaking, &c.

239. For the tongue to taste properly, it must be moist, and the substance to be tasted must be liquid, holding salts in solution.[m] (A) For if either is in a dry state, we may perceive the presence of the substances by the common sense of touch, which the tongue possesses in great acuteness, but cannot discover their sapid qualities.

When the tongue tastes very acutely, the papillæ around its apex and margins seem to be in some degree erected.

NOTE.

(A) Certainly an infinite number of bodies are sapid, which contain no kind of salt.

[g] Ruysch, *Thesaur. Anat.* 1. tab. iv. fig. 6.
B. S. Albinus, *Annotat. Acad.* l. i. tab. i. fig. 6—11.

[h] Consult Haller's excellent description of the tongue of a *living man*, in the *Dictionn. Encyclopédique.* Yverdon, vol. xxii. p. 28.

[i] J. Fr. Meckel, *De Quinto pare Nervorum Cerebri.* Gotting. 1748. 4to. p. 97. fig. 1. n. 80.

[k] J. F. W. Böhmer, *De Nono pare Nervorum Cerebri.* Gotting. 1777. 4to.

[l] See Haller, *Icon. Anatom.* fasc. ii. tab. 1. letter g.
Monro, *On the Nervous System.* Tab. xxvi.

[m] Bellini, *Gustus Organum novissime deprehensum.* Bonon. 1665. 12mo.

Two dissimilar metals in contact, when applied to the moistened tongue, have a decidedly acid taste. It is by no means proved that the moisture indispensable for taste is requisite to dissolve the substance tasted and not to fit the papillæ for their office.

Dr. Nehemiah Grew, an eminent naturalist of the seventeenth century, endeavoured to show that there are at least sixteen different simple tastes, which he enumerates. All these, he states, have various degrees of intenseness and weakness, and may be combined together in an innumerable variety of proportions. Many of these have other modifications; in some the taste is more quickly perceived upon the application of the sapid body, in others more slowly; in some the sensation is more permanent, in others more transient; in some it seems to undulate or return after certain intervals, in others it is constant: the various parts of the organ, as the lips, the tip of the tongue, the root of the tongue, the fauces, the uvula, and the throat, are some of them chiefly affected by one sapid body, and others by another. All these, and other varieties of tastes, Dr. Grew illustrates by a number of examples.[n]

[n] Dr. Reid, *Inquiry into the Human Mind,* c. 3.

SECT. XV.

OF SMELL.

240. While taste and smell are closely related by the proximity of their organs, they are not less so by the analogy of their stimuli and by some other circumstances. For this reason, they have been generally classed together under the name of chemical or subjective senses.

By smell we perceive odorous effluvia received by inspiration and applied principally to that part of the Schneiderian [a] membrane which invests both sides of the septum narium and the convexities of the turbinated bones.

241. Although the same moist membrane lines the nostrils [b] and their sinuses,[c] its nature appears different in different parts.

Near the external openings it is more similar to the skin, and beset with sebaceous follicles, from which arise hairs known by the name of vibrissæ.

On the septum and the turbinated bones it is fungous and abounds in mucous cryptæ.

In the frontal, sphenoidal, ethmoidal, and maxillary sinuses,

[a] Conr. Vict. Schneider, *De Osse Cribriformi et Sensu ac Organo Odoratus.* Witteb. 1655. 12mo.

This classical work forms an epoch in physiological history, not only because it was the first accurate treatise on the function of smell, but because it put an end to the visionary doctrine of the organ of smell being the emunctory of the brain.

[b] Sömmerring, *Icones Organorum Humanorum Olfactus.* Francof. 1810. fol.

[c] Haller, *Icones Anat.* fasc. iv. tab. ii.

Duverney, *Œuvres Anatom.* vol. i. tab. xiv.

Santorini, *Tab. Posthum.* iv.

C. J. M. Langenbeck, *Neue Bibl. für Chirurgie,* vol. ii. P. ii. p. 318. tab. ii.

it is extremely delicate, and supplied with an infinite number of blood-vessels which exhale an aqueous dew.

242. It appears the principal, not to say the sole, use of the sinuses,[d] to supply this watery fluid, which is perhaps first conveyed to the three meatus of the nostrils and afterwards to the neighbouring parts of the organ of smell, preserving them in that constant state of moisture which is indispensable to the perfection of smell.

The sinuses are so placed, that, in every position of the head, moisture can pass from one or other of them into the organ of smell.

243. The principal seat of smell, — the fungous portion of the nasal membrane, besides numerous blood-vessels, remarkable for being more liable to spontaneous hemorrhage than any others in the body, is supplied by nerves, chiefly the first pair,[e] which are distributed on both sides of the septum narium, and also by two branches of the fifth pair. The former appear to be the seat of smell:[f] the latter to serve for the common feeling of the part, that excites sneezing, &c.

244. The extreme filaments of the first pair do not terminate in papillæ, like the nerves of touch and taste, but deliquesce, as it were, into the spongy and regular parenchyma of the nasal membrane.

245. The organ of smell is very imperfect and small at birth. The sinuses scarcely exist. Smell consequently takes

[d] In my *Prolus. de Sinibus Frontal.*, Gotting. 1779., 4to., I have brought forward many arguments from osteogeny, comparative anatomy, and pathological phenomena, to prove that these sinuses contribute indeed to the smell, but little or nothing to voice and speech, as was believed by many physiologists.

[e] Metzger, *Nervorum Primi Paris Historia*. Argent. 1766. 4to. reprinted in Sandifort's *Thesaurus*, vol. iii.

Scarpa, *Anatomic. Annotat.* l. ii. tab. i, ii.

[f] This is shown by pathological dissection and comparative anatomy. Thus in Loder's *Observ. Tumoris Scirrhosi in basi cranii reperti*, Jen. 1779., 4to. is a case of anosmia, following a compression of the first pair by a scirrhus. We learn, from comparative anatomy, that in the most sagacious mammalia, *v. c.* elephants, bears, dogs, bisulcous ruminants, hedgehogs, &c., the horizontal plate of the cribriform bone is very large, and perforated by an infinity of small canals, each of which contains a filament of the olfactory nerve.

place but late,—as the internal nostrils are gradually evolved; and it is more acute in proportion to their size and perfection.[g]

246. No external sense is so intimately connected with the sensorium and internal senses, nor possesses such influence over them, as the sense of smell.[h]

No other is so liable to idiosyncrasies, nor so powerful in exciting and removing syncope.

Nor is any other capable of receiving more delicate and delightful impressions; for which reason, Rousseau very aptly called smell, *the sense of imagination.*[i]

No sensations can be remembered in so lively a manner as those which are recalled by peculiar odours.[k]

[g] While animals of the most acute smell, as those just mentioned, have the nasal organs most extensively evolved, precisely the same holds in regard to some barbarous nations.

For instance, in the head of the North American Indian (a leader of his nation, and executed at Philadelphia about fifty years ago), which I have given in my *Decas prima Collectionis Craniorum diversarum gentium illustratæ,* tab. ix., the internal nares are of an extraordinary size, so that the middle of the ossa spongiosa, for instance, are inflated into immense bullæ, and the sinuses, first described by Santorini, which are contained in them, larger than I have found them in any other instance.

The nearest to these, in point of magnitude, are the internal nares of the Ethiopians, from among whom I have eight heads, now before me, very different from each other, but each possessing a nasal organ much larger than we find it described to be in that nation by Sömmerring, *über die körperl. Verschiedenh. des Negers,* &c. p. 22.

These anatomical observations accord with the accounts given by most respectable travellers concerning the wonderful acuteness of smell possessed by those savages.

Respecting, *v. c.* the North American Indians, consult, among others, Urlsperger, *Nachr. von der Grossbritann. Colonie Salzburg. Emigranten in America,* vol. i. p. 862.

Respecting the Ethiopians, *Journal des Sçavans.* 1667. p. 60.

[h] See Alibert on the medical power of odours, *Mém. de la Soc. Médicale,* t. i. p. 44.

[i] *Emile,* t. i. p. 367.

[k] Respecting the power of smell over morals and propensities, consult Benj. Rush, *Medical Inquiries and Observations,* vol. ii. p. 34.

NOTE.

The causes of the sensation of smelling are, as yet, unknown, and in the absence of positive knowledge on this subject philosophers have either avowed their ignorance or contented themselves with hypotheses destitute of proof. Among the opinions respecting these recondite phenomena which have at various times been advanced, three may merit our consideration. The advocates of the first, designate by *spiritus rector*, or *aroma*, a principle independent of the substances which contain it, very volatile and expansible, imponderable, and imperceptible to every sense excepting that of smell; and to the various modifications of this immaterial substance they attribute the varieties of odour. The second, and most generally received theory, is, that odours are particles which evaporate from the odorous substance itself, and that the cause of the sensation of smell is therefore inherent in, and inseparable from, the odorous body. The third opinion, which is maintained by Professor Walther, is, that olfaction is independent of the emanations of material particles, and is a simple dynamic action of the odorous body upon the organs of smelling, similar to the action of sound on the hearing.

However this may be, odours, to become objects of sensation, must pass the pituitary expansion of the olfactory nerve during the respiratory process. When the breath is held, the most odorous substances may be spread in the interior of the nostrils without their perfume being perceived; this observation was first made by Galen. It has been frequently remarked that odours are smelt only during inspiration, the same air when returned through the nostrils always proving inodorous. But this is true only when the odour has been admitted from without by the nostrils; for when it is admitted by the mouth, as in combination with articles of nutrition, it is only during *expiration* that the odour can be perceived; a proof of this may be readily obtained, by placing the open neck of a small phial, containing an essential oil, in the mouth during the acts of inspiration, and subsequent expiration.

It was first observed by Willis,[1] that on placing a sapid substance in the mouth, and at the same time closing the nostrils, the sensation of taste is suspended. This observation has since

[1] *De anima brutorum*, 1680.

been frequently repeated, and has given rise to the generally prevailing opinion that a very intimate relation exists between the sensations of smelling and tasting, and that the same qualities of bodies simultaneously affect both these senses. The fact is, that the causes of taste and smell are totally distinct in their nature; tastes, properly so called, affect only the gustatory expansion, and are, consequently, unaltered by closing the nostrils; but as most sapid substances have also an odour, and expiration takes place frequently during mastication and generally directly after deglutition, the odorous emanations are made to pass over the pituitary membrane. Odour, which thus accompanies taste, is termed *flavour*.

Sugar, salt, and vinegar, have each a real taste, which can be affected neither by catarrh nor by stopping the nostrils; but the flavour and odour of roast meats, of spices, of liqueurs, &c., are identical, and they are affected equally by the same conditions.

Dr. Prout, I believe, was the first who pointed out the distinction between taste and flavour.[1] He conceived, however, that flavour was intermediate between taste and smell.

[1] *London Med. and Physical Journal.* 1812.

SECT. XVI.

OF HEARING.

247. Sound, (A) which is excited by the vibration of elastic bodies and propagated by the air, is perceived by the sense of hearing,[a] and is first received by the conchiform cartilaginous *external ear*,[b] which few of our countrymen have the power of moving.[c] By this it is collected; then conveyed into the meatus auditorius, which is anointed by a bitter cerumen;[d] (B) and strikes[e] against the *membrana tympani*, (C) which is placed obliquely in a circular furrow of the temporal bone and separates the meatus from the internal ear.

248. Behind this membrane lies the middle portion of the ear, — *the cavity of the tympanum*, whose fundus is directed upwards and inwards.

It contains three[f] *ossicula auditus;* of which the exterior, or *malleus*, adheres by its manubrium to the membrana tympani, and is generally united in the adult to the circular furrow above-mentioned by its spinous process which is directed forwards, and it lodges its round head in the body of the *incus.*

The incus is united to the head of the *stapes* by the ex-

[a] Sömmerring, *Icones organor. humanor. auditus.* Francof. 1806. fol.

[b] B. S. Albinus, *Annotat. Academ.* l. vi. tab. iv.

[c] V. J. Rhodius ad Scribon. Largum. p. 44. sq.

J. Alb. Fabricius, *De Hominibus ortu non differentibus.* Opuscul. p. 441.

Ch. Collignon, *Miscellaneous Works.* Cambridge. 1786. 4to. p. 25. sq.

[d] Consult J. Haygarth, *Med. Obs. and Inquiries,* vol. iv. p. 198. sq.

[e] See the distinguished Himly's acute comparison of the organs of hearing and vision, *Bibliothek für Ophthalmologie,* vol. i. p. 6. sqq.

[f] The existence of a fourth bone (called *lenticular*), commonly admitted since the time of Franc. Sylvius, I have disproved at large in my Osteology, p. 155. sq. edit. 2. It is wanting in the greater number of perfect examples from adults.

tremity of its long process which extends into the cavity of the tympanum.

The stapes, resting its base upon the fenestra ovalis, runs towards the vestibule of the labyrinth, into which, sounds, struck against the membrana tympani, are propagated by the intervention of these three little bones.

249. The Eustachian *tube*[g] runs from the interior of the fauces into the cavity of the tympanum: and the inferior scala of the cochlea has the same direction; the opening of the latter, termed *fenestra rotunda*,[h] is closed by a peculiar membrane. The true and principal use of each is not sufficiently known.[i]

250. In the deepest part of the petrous bone is placed the labyrinth, or *internal ear*, consisting of three parts.

First, of the *vestibule*, placed between the other two, and into it open not only the fenestra ovalis, but the five orifices of the *semicircular canals* which lie posteriorly, and the superior scala of the *cochlea* which is placed anteriorly.

The vestibule and semicircular canals loosely contain very delicate membranous bags, discovered by the celebrated Scarpa: viz, two sacs which lie in the vestibule, and three semicircular ducts in the canals of the same name.[k]

251. These sacs as well as the cavity of the cochlea, contain a very limpid fluid, bearing the name of Cotugno, who shewed it to be absorbed by two canals, which are by him denominated *aqueducts*,[l] and by Meckel *diverticula*;[m] the one arises

[g] Saunders, *Anatomy of the Human Ear.* Lond. 1806. fol. vol. i. ii.

[h] Scarpa, *De Structura Fenestræ Rotundæ*, &c. Mutin. 1772. 8vo.

[i] Comparative anatomy renders it most probable that the Eustachian tube is subservient to the action of the membrana tympani. It is found in all red-blooded animals which possess a membrana tympani, but is wanting in fishes which are destitute of this membrane. The different opinions of the moderns respecting its use, may be found in Reil's *Archiv. für die Physiol.* t. ii. p. 18. iii. p. 165. iv. p. 105. viii. p. 67. ix. p. 320.

[k] Scarpa, *Disquisitiones Anatomicæ de Auditu et Olfactu*, tab. iv. fig. 5. tab. vii. fig. 3.

[l] Cotunni, *De Aquæductibus auris humanæ.* Neap. 1761. 4to.

[m] Ph. Fr. Meckel, *De Labyrinthi auris contentis.* Argent 1777. 4to.

from the vestibule, the other from the inferior scala of the cochlea.

252. The portio mollis of the seventh pair, together with the portio dura (which afterwards runs along the *aqueduct* of Fallopius),[n] having entered the internal acoustic opening, transmits its medullary filaments into the lower and cribriform part of it.[o] These filaments run partly to the vestibule and semicircular canals, but especially to the base of the cochlea, where, in the form of a medullary zonula, marked by very beautiful plexiform striæ, they pass between the two laminæ of the septum cochleæ.[p]

253. The oscillatory tremor, which we formerly followed as far as the fenestra ovalis (248), is propagated to the vestibule, where, by means of the water of Cotugno (251), it strikes the auditory nerves distributed among the windings of the labyrinth.

254. Besides the muscles of the malleus and stapes,[q] that appear to be voluntary,[r] the chorda tympani,[s] passing between the handle of the malleus and the longer leg of the incus, is believed to modify the force of sound which is struck against the membrana tympani and intended to be propagated along the cavity of the tympanum.[t] (D)

[n] Fallopius, *Observ. Anat.* p. 27. b. sq. Venet. 1561. 8vo.

[o] Consult Brendel, *Analecta de Concha auris humanæ.* Gotting. 1747. 4to. The same, *De Auditu in apice conchæ*, Ib. eod. 4to.

[p] Consult Zinn, *Observ. Botan.* Gotting. 1753. 4to. p. 31. sq. Scarpa, l. c. tab. viii. fig. 1, 2.

[q] B. S. Albinus, *Tabulæ Muscul.* tab. xi. fig. 29.

[r] Eustachius, *De Auditus Organ.* p. 157. Caldani, *Institut. Physiol.* 245. sq.

[s] J. Fr. Meckel, *De Quinto pare Nervorum Cerebri*, fig. 1. *x*. 71. Leop. M. A. Caldani on the office of the chorda tympani, *Saggi dell' Acad. di Padova*, t. ii.

[t] Cotunni, l. c. § lxxxviii. Marherr, *Prælect. in Boerhaavii Inst.* vol. iii. p. 343.

NOTE.

(A) By Hearing we are able to appreciate the vibratory motions of elastic bodies, when their frequencies are within certain limits. Some recent experiments by Dr. Wollaston prove that these limits vary in different individuals; but the average extent of the scale of sounds perceptible to the human ear has been estimated to be between 30 and 12,000 vibrations of the sonorous body per second.

The undulations to which these vibrations give rise may be transmitted through any substance, either aëriform, liquid, or solid: but the air is the ordinary medium by which they reach the ear. The velocity of transmission depends on the specific elasticity of the substance; according to the latest experiments sound travels through air at the rate of about 1142 feet per second.

With regard to the sensation of sound, four independent qualities must be distinguished:[u]

1st. The *tune*, or *pitch;* which depends on the frequencies with which the vibrations succeed each other.

2d. The *loudness*, or *intensity;* which is determined by the amplitudes of the vibrations.

3d. The *volume*, or *richness;* which depends upon the number of co-existing undulations that arrive at the ear.

4th. The *timbre:* — For this word, adopted in France to express the specific differences of sound which are not comprehended in any of the preceding definitions, there is no analogous term in our language; nor have we at present the least idea of the true causes of these modifications of sound. In some cases the indefinite expression *quality of tone* is employed.

When two or more sounds are heard simultaneously, or successively, the mind by a peculiar faculty perceives the relative frequencies and coincidences of the vibrations. Two sounds are regarded, as consonant when the ratio of their vibrations is very simple, and as dissonant when the ratio is more complex. The rules which determine the most agreeable successions and combinations of sounds constitute the science of music.

[u] C. Wheatstone, *Experiments on Sound. Annals of Philosophy.* New Series. vol. vi. p. 81.

The power of appreciating musical combinations, and consequently the pleasure of listening to them, depends upon a mental faculty seated in a particular portion of the brain, and not upon the acuteness of hearing. A person of the quickest ears may have no music in his soul, and persons of dull ears have often a good *ear for music*. In great musicians, that portion of the skull corresponding with the part of the brain that Gall declares to be the organ of music, I have invariably seen large; and in persons slightly, or not at all sensible to the delights of music, invariably flat, or even hollow.

(B) The cerumen consists, according to Vauquelin, of albumen, which, when burnt, yields soda and phosphate of lime, a colouring matter, and a very bitter inspissated oil strongly resembling the peculiar matter of bile. Cicero explains one use of the cerumen: — "Provisum etiam, ut, si qua minima bestiola conaretur irrumpere, in sordibus aurium, tanquam in visco, inhæresceret." [x] The same applies to particles of dust. Its extreme bitterness, too, deters insects from advancing.

(C) The membrane of the tympanum is not of that importance which the prevailing hypothesis induced physiologists to believe formerly. It may be perforated and even obliterated, and yet the faculty of hearing will remain uninjured. Its uses appear to be chiefly preservative. The mechanism which has been devised to bring the membrane to vibrate in unison with different sounds is entirely imaginary; for it is evident, from the known laws of vibrating surfaces, that its condition is always such as to render it susceptible of being influenced by any sound whatever.

When the membrana tympani is stretched by the internal muscle of the malleus, the amplitudes of its vibrations are diminished, and the sound is transmitted to the internal ear, through the fenestra ovalis, with less intensity; when, on the contrary, it is relaxed, by the action of the anterior muscle of the malleus, the amplitudes are rendered greater, and the sound is transmitted with greater intensity. These results, which Dr. Savart has established by experiment, are in direct opposition to the conjectures of Bichat. [y]

[x] *De Natura Deorum*. l. ii.

[y] Savart, *Recherches sur les Usages de la Membrane du Tympan et de l'oreille externe*. *Annales de Chimie*, t. xxvi. p. 5.

(D) Some curious and original observations and experiments on the functions of hearing, will be found in a paper by Dr. Wollaston "On Sounds inaudible to certain Ears,"[z] and in Mr. C. Wheatstone's "Experiments on Audition."[a] Savart's memoir, already mentioned, will be found also to contain some facts worthy of notice.

[z] *Phil. Trans.* 1820.

[a] *Journal of Science.* New Series, vol. ii. p. 67. sqq.

SECT. XVII.

OF SIGHT.

255. The instruments of vision, — the eyes,[a] are two moveable globes, fixed to the optic nerves, whose decussation we formerly noticed (211), as it were to stalks, in such a manner, that their insertion is not exactly opposite the centre of the cornea and iris, but on one side of this imaginary axis, — rather nearer to the nose.

256. They consist of various coats containing pellucid humours of different densities, so placed that the rays of light can pass from the transparent anterior segment of the bulb to the opposite part of the fundus.

257. The external coat is called *sclerotic*. It is deficient in the centre, and that part is filled up by the *cornea*, which is transparent, lamellated (lined internally by the *membrane of the aqueous humour*, or of Demours), more or less convex, and projects like the segment of a small globe from one of rather larger size.[b]

258. The interior of the sclerotica is lined by the *chorioid*, which abounds in blood-vessels,[c] especially vorticose veins,

[a] San. Th. Sömmerring, (the father) *Icones oculi humani*. Francof. 1801. fol.

Detm. W. Sömmerring, (the son) *De oculorum sectione horizontali Commentarius*. Gotting. 1818. fol.

[b] G. H. Gerson, *De Forma Corneæ deque singulari Visus Phænomeno*. Gotting. 1810. 4to.

Al. Clemens, *Tunicæ Corneæ et Humoris Aquei Monographia*. Gotting. 1816. 4to.

M. J. Chelius, *über die durchsichtige Hornhaut*. Carlsr. 1818. 8vo.

[c] Sam. Th. Von Sömmerring, in the *Denkschr. der Akad. der Wiss. zu München*. 1817. tab. I.

and is covered on each side by a black pigment, which adheres but loosely to its concave surface in the form of mucus.[d]

259. The chorioid is internally coated by the *retina*[e] — a medullary expansion of the optic nerve after this has passed through the sclerotica and chorioid,[f] of most beautiful texture,[g] and perforated, in the imaginary axis of the eye, between the two principal twigs of the central artery,[h] by the singular central foramen of Sömmerring,[i] which is surrounded by a yellow edge.[k] (A)

260. The anterior edge of the chorioid is terminated by a cellular belt, called *orbiculus ciliaris*, by which it adheres firmly to a corresponding groove in the sclerotic, and from which two other membranes of a different kind, viz. the iris and ciliary processes, are expanded in a circular form.

[d] C. Mundini, in the *Comm. Instit. Bononiens.* t. vii. p. 29.

H. F. Elsaesser (præs. G. C. Ch. Storr), *De pigmento oculi Nigro.* Tubing. 1800. 8vo.

[e] B. S. Albinus, *Annotat. Academ.* l. iii. p. 59. sq. l. iv. p. 75. sq. l. v. p. 66. sq.

[f] Walter, *De Venis Oculi*, &c. Berol. 1778. 4to. tab. i. fig. 2. tab. ii. fig. 2.

[g] The extremely beautiful blood-vessels of the retina were first discovered by J. Mery to be visible in a living cat plunged under water, *Mém. de l'Acad. des Sc. de Paris. avant* 1699. t. x. p. 650; and 1704. p. 265.

The most beautifully radiated surface of the retina in the hare was displayed by Zinn in an admirable engraving. *Comm. Soc. Scient. Gotting.* t. iv. 1754. tab. viii. fig. 3.

By Fontana, in the rabbit, *Sur le vénin de la vipère*, vol. ii. tab. v. fig. 12.

[h] A plate accurately representing the course of these branches will be found in the *Œuvres de* Mariotte, p. 527. fig. 1.

[i] Sömmerring, *De Foramine centrali limbo luteo cincto retinæ humanæ:* in the *Comment. Soc. Reg. Scient. Gottingens.* t. xiii.

Ph. Michaelis, *Journal der Erfindungen in der Natur-und Arzneywiss*, P. xv.

[k] As I have discovered this central aperture in the eye of no animal besides man, except the *quadrumana*, the axes of whose eyes are, like the human, parallel to each other, I think its *use* connected with this parallel direction of the eyes, and have endeavoured to explain the connection at large, in my *Handbuch der vergleichenden Anatomie*, p. 402. sq. 2d edit.

As, on the one hand, this direction of the eyes renders one object visible to both at the same time, and therefore more distinctly visible; so, on the other, this foramen prevents the inconvenience of too intense a light, if there is a probability that it expands and dilates a little under this circumstance, and thus removes the principal focus from the very sensible centre of the retina.

261. The *iris* (whose posterior surface is lined by a brown pigment, and termed *uvea*), lies anteriorly to the ciliary processes, is flat, and washed on all sides by the aqueous humour; narrower towards the nose, broader towards the temples. Its texture is dense and cellular, and contains no vestige of muscular fibre. We must regard it, with Zinn,[l] as a membrane sui generis, and not as a prolongation of the chorioid. The anterior surface is differently coloured in different persons, and, during life, has a flocculent appearance.[m]

262. The blood-vessels of the iris run chiefly on its anterior surface, and in the fœtus are continued into the *membrana pupillaris*,[n] which begins to open in its centre at the seventh or eighth month of pregnancy,—when the eyes have acquired some degree of size, and when, probably, the elliptic arches of its vessels begin to be gradually retracted into the *inner ring of the iris*, which ring I have never been able to perceive distinctly before that period.

263. The posterior of the two circular membranes (260) bears the name of *ligamentum* or *corpus ciliare;* and, inclining backwards, lies at a distance from the iris. Its external edge is thick[o] and adheres to the ciliary circle (260): the internal is thin, and, together with the adjacent *zonula* of Zinn,[p] surrounds the margin of the capsule of the lens. The brown pigment is copiously diffused over it.

Its anterior surface, lying opposite to the uvea, is striated.

The posterior, lying upon the vitreous humour, is marked

[l] *Comment. Soc. Scient. Gotting.* tom. iv. p. 199.

[m] On the remarkable mutual relation of the arteries and nerves of the internal parts of the eye, and especially of the iris, see Diet. G. Kieser, *De Anamorphosi Oculi.* Gotting. 1804. 4to.

[n] This beautiful membrane was first discovered by Francis Sandys — a celebrated maker of anatomical preparations: it was first described and exhibited in an engraving by Ever. J. Wachendorf, *Commerc. Litter. Nor.* 1740. hebd. 18.

[o] The ciliary canal, discovered by Fel. Fontana, (*Sur le vénin de la vipère,* vol. ii. tab. vii. fig. 8, 9, 10.) and afterwards described more accurately by Adolp. Murray (*nov. act. Upsaliens,* vol. iii.), runs, in bisulcous animals, along this thick edge.

[p] Doellinger, *Nov. Act. Ac.* N.C. t. ix. p. 267. sqq. tab. vii.

C. J. M. Langenbeck, *Neue Bibl. für die Chirurgie,* iii. B. 1. St. tab. 1. 11.

by about seventy plicæ, which are beautifully flocculent, and remarkable for a set of indescribably minute and elegant blood-vessels. These flocculi are named *ciliary processes*, and their use is still an object of enquiry.[q]

264. In the bulb of the eye, whose coats we have now described, are contained the *humours*, of three principal kinds.

The posterior, and by far the greater, part of the globe is filled by the *vitreous* humour, which is in larger quantity proportionally in the human subject, especially after puberty, than in other animals, and so dispersed in innumerable drops throughout the cells of the delicate *hyaloid membrane* that this membranaceo-lymphatic body has the singular appearance of a tremulous jelly.

265. Anteriorly it adheres to, and, the *zonula* just mentioned surrounds, the capsule containing the *crystalline lens*, immediately around which lies the water of Morgagni.

The lens itself also very pellucid is cellular, but so much more dense than the vitreous humour, that in the hand it seems like a very tenacious, although an amazingly clear, gluten. Its nucleus is more dense than the exterior laminæ. The laminæ may be reduced into extremely delicate fibres, converging from the circumference to the centre.[r]

In an adult man the lens is proportionally to the whole body smaller than in quadruped mammalia; also less convex, especially on its anterior surface.

266. The remaining space of the eye is filled by the *aqueous humour*, which is very limpid, and divided by the iris into two *chambers*: — the anterior and larger separating the cornea and iris; and the posterior, in which the uvea lies towards the corpus ciliare, so small, as scarcely believed by some to exist.

[q] Consult, among others, Brandis, *Pathologie*, p. 253.

And J. Aug. Hegar, *De Oculi partibus quibusdam*. Gotting. 1818. 8vo. p. 25. sqq.

[r] Th. Young, *Phil. Trans.* 1795. tab. xx. fig. 2, 3.

Dav. Hosack, ib. 1794. tab. xvii. fig. 4.

J. C. Reil, *De lentis crystallinæ structura fibrosa*. Hal. 1794. 8vo.

267. These most valuable parts are defended from injury both by the depth of their situation in the orbits and by the valvular coverings of the eye-lids.

In the duplicature of the *palpebræ*, lie the *sebaceous follicles* of Meibomius,[s] thickly distributed: and their edges are fringed by a triple or quadruple series of *cilia:*[t] the cartilaginous *tarsi* serve for their support and expansion, and also facilitate their motion upon the eye-ball.

Above the eye-lids, to use the language of Cicero, are placed the *supercilia*, which preserve the eyes from the sweat flowing from the head and forehead, and in some measure screen them from too strong a light.

268. To lubricate the eyes, to preserve their brightness, and to wash away foreign matters, is the office of the *tears;* the chief source of which is a conglomerate gland placed in the upper and exterior part of the orbit. It has numerous but very fine excretory ducts, which are said to discharge about two ounces of tears upon each eye during the twenty-four hours: the tears are afterwards absorbed by the puncta lachrymalia, the function of which may, in a certain sense, be compared to that of the lacteals in the villous coat of the small intestines; from the puncta they are conveyed through the snails' horns, as they are called, into the lachrymal sac, and thence pass into the lower meatus of the nostrils.[u] (B)

269. Thus much it was necessary to premise upon the structure of the organ of vision. We now come to the function of the organ, — to the explanation of vision.

Rays of light falling upon the cornea at an angle more acute than forty-eight degrees, pass through it, and, from both its density and figure, are considerably refracted towards the axis of the eye, and on entering the aqueous humour they experience rather a less degree of refraction.

Those rays which penetrate the pupil and are received by

[s] H. Meibomius, *De vasis Palpebrarum novis ep.* Helmst. 1666. 4to.

[t] B. S. Albinus, *Annotat. Academ.* l. iii. tab. iii. fig. 4.

[u] J. Chr. Rosenmüller, *Organor. Lachrymalium Partiumque Externarum Oculi Humani Descriptio Anatomica.* Lips. 1797. 4to.

the lens, are still more refracted on account of the greater density of this medium.

The less density of the vitreous humour prevents the focus of rays from being too short, and allows it to fall upon the retina and exhibit the image of objects, though, from the laws of light, necessarily inverted.

270. The *focus* which thus falls upon the retina, is considered as a point, not absolutely, but, on account of the different refrangibility of colours, relatively; yet the latitude necessarily arising from this aberration of the rays is so small that it not only does not obscure the distinctness of vision in any perceptible degree, but is the source of many advantages.[x]

271. The celebrated question — why we behold objects erect, while their image is inverted upon the retina,[y] may be easily answered, by considering that objects are called inverted relatively only to those which appear erect.

Now, since the images of all objects and of our own bodies are painted on the retina, each in its relative situation, this relative situation must correspond as exactly as if they were viewed erect, so that the mind (to which a sensation excited by the image and not the image itself is communicated) is preserved from all danger of error. (C)

272. Since many conditions are requisite for distinct vision, the Creator has wonderfully ordered the functions of these organs.

A sufficient, but, at the same time, a definite, quantity of light, not too intense for distinct vision, is provided in two modes: — First, according to the greater or less intensity of the rays, a greater or less number of them pass to the lens; — Secondly, that portion which is superabundant and injurious to vision is absorbed.

The first point is effected by the motion of the iris; the second, by the pigmentum nigrum.

[x] Nev. Maskelyne, *Attempt to explain a Difficulty in the Theory of Vision, depending on the different Refrangibility of Light,* in the *Philosophical Transactions,* vol. lxxix. p. 256.

[y] J. H. Voight, *Magazin für Physik und Naturgeschichte,* t. v. P. iii. p. 143.

273. The iris is endowed with remarkable mobility, and thus accommodates itself to the intensity and distance of light, so that, when exposed to a strong light or to near objects it may expand itself and contract the pupil, but when to a weaker light or more remote objects it may contract itself and dilate that opening.[z]

Physiologists have given different explanations of this motion. Some ascribe it to the varied impulse of blood into the vessels, others to contraction of the imaginary muscular fibres of the iris. I have shown, in a particular treatise, that both these circumstances are impossible, and that its proximate cause may be sought for with more probability and reason in the vita propria of the iris (42); the more remote cause, as we formerly hinted (56), can be solely the reaction of the sensorium.[a]

274. The function of the dark pigment, so frequently mentioned, (258, 261, 263,) viz. to absorb the superfluous rays, and, consequently, its importance to the perfection of vision, are demonstrated, among other modes, by the dissection of different kinds of animals, and by the diseased condition of Albinos, whose eyes are very tender and impatient of light from the absence of this pigment.[b]

275. The focus of the refracted rays must fall exactly on the retina, so that the point of vision be neither produced beyond it nor fall within the vitreous humour.

The latter defect exists in short-sighted persons, from the too great convexity of the cornea or gibbosity of the lens.

The former is the defect of long-sighted persons, in whom there is the opposite conformation of parts.

276. Since a perfect and sound eye beholds near and remote objects with equal distinctness, it must of necessity be

[z] Zinn, *De Motu Uveæ*, 1757. in the *Comment. Societ. Scient. Gotting.* t. i. Fel. Fontana, *Dei Moti dell' Iride.* Lucca. 1765. 8vo.

[a] For other explanations consult Troxler in Himly's *Ophthalmol. Biblioth.* t. i. P. ii. p. 21.

[b] I have spoken of Albinos at large in my work, *De Generis Humani Varietate Nativa*, ed. 3. p. 274; and in my dissertation, *De Oculis Leucæthiopum.*

supplied with appropriate powers of accommodation.[c] That these internal changes of the eye are chiefly accomplished by the pressure of the straight muscles of the ball, I am clearly convinced, from this among other arguments, — that in the Greenland whale — an amphibious animal, which must see in media of such different densities, nature has most accurately provided for it, in the remarkable structure and obsequious flexibility of the sclerotica.[d] (D)

277. During the waking state, the eyes are perpetually, although unconsciously, agitated, and directed towards the axes of objects, by these muscles. (E)

For, although the whole of the retina is sensible, it is not throughout equally calculated to receive the images of objects.

In the first place, the true axis of the human[e] eye, where the optic nerve enters, is proved, by the well-known experiment of Mariotte,[f] to be nearly insensible to light. (F)

The *principal focus* of the rest of the retina, and which must be considered as the chief instrument of distinct vision, falls upon an imaginary axis of the globe, corresponding with the centre of the cornea and of the whole eye. This, however, as Kaestner observes in opposition to Boerhaave, is not to be understood as if only one point of an object could be seen distinctly at once, the eye being fixed, and that, to behold another point, the axis of the eye must be changed; for the sensation of an entire object is simple and complete.[g]

278. The habit of directing the axes of the eyes rapidly towards objects is acquired by practice. This is proved by the example of persons who were born blind but recovered

[c] H. W. Math. Olbers, *De Oculi Mutationibus Internis*. Gotting. 1780. 4to. Ever. Home, *Phil. Trans.* 1795. P. 1.

[d] *Comment. Societ. Scient. Gottingens.* t. vii. p. 62. fig. ii. f. g. h.

[e] I say the human eye; for in some animals now before me, the seal and porcupine, for instance, the true and imaginary axis are the same, the optic nerve lying exactly opposite the centre of the cornea and pupil.

[f] Troxler speaks of this at large, l. c. t. ii. P. ii. p. 1.

[g] *In Optica Quædam* Boerhaavii et Halleri *Commentatur* Abr. Gotth. Kaestner. Lips. 1785. 8vo. p. 7.

their sight after puberty;[h] and of children, who seldom acquire this facility of motion before the third month.

279. To habit we must ascribe also the circumstance of beholding an object singly, although we have two eyes.[i] For infants at first see double, and the double vision which occasionally occurs after certain diseases of the eyes may be removed by practice and experience. (G)

280. The combined power of the two eyes does not exceed, according to Jurin, that of each, by more than one thirteenth part.

It is needless to add, what the celebrated painter, Leonardo da Vinci, long since remarked, — that, in viewing distant objects, it is preferable to employ but one eye.[k]

281. An object can never be seen unless the angle of vision exceeds 34 *seconds*. This was proved by the very beautiful experiments of the acute Tob. Mayer, who formerly was one of our number: and he demonstrated the great perfection of the human sight, by showing that this still remained the limit of vision in any light, — in the splendor of the meridian sun and the faint light of a lantern; so that vision remains almost equally distinct although the light be considerably diminished.[l]

282. We may hence infer the extreme minuteness of the images of objects projected upon the retina,[m] and nevertheless impressed so forcibly upon it, that, under certain circumstances, their vestiges remain after the removal of the objects from before the eye.[n]

[h] See Giov. Bortolazzi, *Sopra una cieca nata guarita.* Verona, 1781. 8vo. p. 99. sq.

[i] W. C. Wells, *Essay upon Single Vision with Two Eyes.* Lond. 1792. 8vo.

[k] Consult Lambert, *Sur la partie photométrique de l'art du peintre* in the *Mém. de l'Acad. des Sciences de Berlin,* 1768. p. 80. sq.

[l] Tob. Mayer, *Experimenta circa visus aciem,* in the *Commentar. Soc. Scient. Gottingens,* t. iv.

[m] De la Hire, *Accidens de la Vue,* p. 375.

[n] Gassendi, *Vita* Peireskii. p. 175. sq. Hague, 1655. 4to.

Franklin, *Letters on Philosophical Subjects,* at the end of his *Expts. on Electricity.* Lond. 1769. 4to. p. 469. sq.

NOTES.

(A) A delicate transparent membrane has been discovered by Dr. Jacob, of Dublin, between the retina and chorioid, and adherent to both.[o]

(B) The tears appear to me to pass over the ball of the eye as low as the edge of the superior tarsus, which is so applied to the ball as not ordinarily to allow of their ready escape under it.[p] As the upper lid descends and nearly covers the front of the eye during sleep, for the lower has but little motion, and the fine inner edges of both meet, the whole of the ball is at this time readily preserved moist. But when the eyes are open, the front of the eye between the lids would not be moistened unless the upper tarsus occasionally descended with the fluid contained behind it. A portion of the fluid thus brought down upon the front of the eye, remains after the upper lid rises again after winking, and trickles by its gravity as far as the inferior tarsus, which, ascending a little as often as the superior descends, raises it somewhat. Winking thus preserves the front of the eye constantly moist during the waking state.

It may be also observed that, when the tarsi approximate, as they drive before them the moisture of the front of the eye-ball, they quite inundate the puncta lachrymalia, by which circumstance the puncta are, of course, enabled to carry off a large quantity of the secretion, and ordinarily to prevent its overflow, which would occur at the centre of the lower tarsus. During sleep the puncta are not so copiously supplied, as they have only the same share of tears as the eye in general; and there is less occasion for it, because the removal of the stimulus of air and light by the closure of the eyelids, lessens the secretion.

Dr. Magendie has found the matter of the tarsal or Meibomian

Rob. War. Darwin, *Experimenta nova de spectris s. imaginibus ocularibus, quæ objectis lucidioribus antea visis, in oculo clauso vel averso percipiuntur.* Lugd. Bat. 1785. 4to.

Er. Darwin, *Zoonomia*, t. i.

C. Himly, *Biblioth. Ophthalmolog*, t. i. P. ii. p. 1.

[o] *Phil. Trans.* 1819. Also, on various other points in the anatomy of the eye, *Med. Chirurg. Trans.* vol. xii. P. 2.

[p] The object of this firm application of the tarsi to the eye must be the exclusion of foreign matters from the orbit.

glands to be not sebaceous but albuminous, and soluble in the tears: hence we discover why, during sleep, it accumulates on the tarsi, — because its solvent — the tears, are not sufficiently abundant to remove it.

(C) The notion of our originally seeing objects upside-down, double, and all as at the same distance, till experience lends its aid, has been satisfactorily refuted by Bishop Berkeley and others. The organs of sight, and all the others of sense, present, when perfect, a perfect impression to the inward senses — the faculties for judging of persons or forms, distance, colour, &c., and nothing farther: these do the rest. The eyes of infants are not originally fit for vision: they are at first absolutely insensible to light for some time, and become qualified for their office gradually. But those animals who are are born with perfect eyes, see perfectly the first moment they enter into the world. [q] Indeed, no experience will make us perceive objects differently from what the external organs present them. Experience tells us that the trees at the end of an avenue are as high as those near us, yet we still see them diminutive; and that a stick placed in water is straight, but it continues to appear crooked. My reader must consult Gall, Dr. Spurzheim, and also Mr. Combe from page 256 to 339.

Persons, all having excellent eyes, and seeing perfectly well, differ much in their powers of recognising persons, finding their way, &c. In none of these points is the difference so striking as with respect to judging of colours. It is by no means uncommon to meet with individuals whose eyes appear excellent, and whose sight is excellent, and who may judge of form and distance correctly, but who cannot distinguish certain colours. Dr. Nicholl describes a boy who confounded green with red, and

[q] A beautiful fact, witnessed by Sir James Hall, is mentioned by Sir George Mackenzie, *Phrenological Essays*, p. 38. He had been engaged in making experiments on hatching eggs by means of artificial heat, and, on one occasion, observed, in one of his boxes, a chicken in the act of breaking from its confinement. It happened, that, just as the creature got out of the shell, a spider began to run along the box, when the chicken darted forward, seized, and swallowed it. In this case it was not merely the eye that was perfect, but innate powers of knowing instantaneously what was proper for it as food, of judging of distance, and of putting its limbs into action. Garin, a young man twenty-four years of age, when recovered from original blindness by an operation, saw objects in their natural position and not reversed. *Expérience Métaphysique, ou Dévelopement de la Lumière et des Sensations*, par Jauffret. 1810.

called light red and pink, blue. His maternal grandfather, and one uncle, had the same imperfection. This uncle was in the navy, and, having a blue uniform coat and waistcoat, purchased a pair of red breeches *to match.*[r] Dr. Nicholl mentions a gentleman who could not distinguish green from red. The grass in full verdure always appeared to him what others call red; and ripe fruit on trees he could not distinguish from the leaves; a cucumber and a boiled lobster were of the same colour in his sight, and a leek resembled a stick of sealing-wax. This person had a brother and a niece — the daughter of another brother — in a similar predicament.[s] Indeed, the defect has frequently occurred in several members of the same family, and frequently has been hereditary, sometimes passing over a generation, like other peculiarities of structure. It is observed more frequently, perhaps, in men. In the rarest and most extreme cases, no colour is distinguished, all objects appearing in this respect alike. In all the cases in which the point has been examined, the part of the cranium under which, according to Gall, the organ for judging of the harmony of colours is placed, is flat, or depressed. I have seen several of these cases, and in all this was the fact. In painters, remarkable for their excellence of colouring, this part is full, or prominent. The contrast between this part of the forehead in a person who has this defect, and in another excelling in the power of colouring, placed side by side, is very striking.

Mr. Dugald Stewart remarks, that "in the power of conceiving colours there are striking differences among individuals;" and he does not ascribe the difference to the eyes. "I am inclined to suspect," he says, "that in the greater number of instances the supposed defects of sight ought to be rather ascribed to a defect in the power of conception."[t] Mr. Stewart is correct in exempting the eye from blame, and ascribing the defect to a defect in conception; but since he has no idea of a distinct faculty for colours, he means conception in general. Yet, as the individuals are not deficient

[r] *Med. Chir. Trans.* vol. vii.

[s] l. c. vol. ix. A case communicated to Dr. Priestley will be found in the *Phil. Trans.* 1777. The man had three brothers with the same defect. In the *Phrenol. Trans.* is another by Dr. Butter. In the *Manchester Memoirs,* vol. v., are others. One such person painted a man's head with a *green* beard and *blue* cheeks. In Mr. G. Combe's *System of Phrenology,* and the *Phrenological Transactions,* are mentioned one of three brothers and a cousin, who inherited it from their maternal grandfather, the intervening generation not having it.

[t] *Elements of the Philosophy of the Human Mind,* ch. iii.

in other conceptions, some reason must be given for the deficiency of conception in this one point. He thinks it arises "probably in consequence of some early habit of inattention." Now this is sad trifling in a philosopher. What particular attention do children, who distinguish colours accurately, bestow? They distinguish without effort; and those who cannot, are not only not proved to have been inattentive, but have, probably, been often extraordinarily attentive, in the hope of seeing what others can see. How should want of attention to this one point run in families and be hereditary, passing through a generation, &c.? This is a specimen of the errors of metaphysicians. They see, and generally acknowledge, that the brain is the organ of the mind, yet they observe the faculties of the mind without even once looking at the organ, which possesses, or is employed in the working of, these faculties. Gall examined the two together, and we now know, that local deficiency of brain exists where the power of distinguishing colours is deficient, and is hereditary with this deficiency.

(D) The most recent opinion on the causes of the adaptation of the eye to distinct vision, a subject on which innumerable conjectures have been made, is that of Jean Mile of Warsaw.[u] By a great number of accurate and satisfactory experiments, for which I refer the reader to the original memoir, he has arrived at the following conclusions.

The eye does not see with equal distinctness objects at all distances, but only when they are within a certain distance. This does not depend on external causes, such as the diminution of the optic angle, and the obscuration of the object by the intermediate air; for, to see clearly and to see distinctly are not identical. The causes of distinct vision are internal, and situated in the eye itself; they are two in number; one disposes the eye for the continuous distinct vision, and the other for the transient distinct vision of objects at different distances; but neither of them can act but within certain limits. These limits are greater for the presbyope than for the myope. These adaptations both depend on the action of the iris, which can at the same time act in two ways to produce two effects; first, the contraction of its aperture,

[u] *De la cause qui dispose l'œil pour voir distinctement les objets placés à différentes distances:* par Jean Mile (traduit du Polonois). Magendie, *Journal de Physiologie*, tom. vi. p. 166.

and, secondly, the flexion of the cornea; the alteration of the size of the pupil, however, is visible only. The adaptation of the eye for the continuous distinct vision of objects contained within certain limits, is owing to the diffraction of the rays of light near the edge of the aperture of the iris, in consequence of which there is formed by a single external luminous point, several foci instead of one, successively ranged in a line of a certain length, so that the object may change its distance within certain limits, and yet one of its foci shall always fall on the bottom of the eye. This focal length is inversely as the magnitude of the pupil. The borders of indistinct objects appear radiated, and to the phenomenon of confusion is added the motion and multiplication of the image when the edges of bodies are brought near the side of the fasciculus of rays which enter the eye; prismatic colours also appear. All these phenomena which are observed in an eye performing its functions, may be produced by an apparatus, the structure of which resembles that of the eye, and even by a common lens, substituting for the motion of the pupil diaphragms of different sizes. The nature of all these phenomena prove that diffraction is their common origin, and they may be considered as constituting a separate kind of optical illusions resulting from diffraction. The second cause which adapts the eye for the momentaneous distinct vision of objects, depends neither on the action of the external muscles of the eye, the advancement of the bottom of the eye, nor on any alteration of the form or position of the crystalline lens, but appears to be owing rather to the change of the curvature of the cornea by the contraction of the iris, which occurs only when the eye adapts itself to see very near objects, as is proved by the simultaneous approximation of the pupil.

(E) The motions of the eyes which result from the actions of their external muscles have been investigated, and the mental perceptions attending them have been analysed with considerable success by Dr. Wells;[x] and the subject has recently been again taken up by Mr. C. Bell.[y] An extensive field of enquiry, however, still remains. Mr. Charles Wheatstone is about to publish

[x] *Essay upon Single Vision with Two Eyes. Phil. Trans.* 1792.
Experiments and Observations on several Subjects in Optics. Phil. Trans. 1811.

[y] *On the Motions of the Eye in Illustration of the Uses of the Muscles and Nerves of the Orbit. Phil. Trans.* 1823.

some original experiments on this subject that will go a considerable way towards completing our knowledge of this intricate and important subject.

(F) Mariotte's experiment was to make two spots upon a wall, to fix the right eye upon the left spot, the other being closed, or v. v. and gradually to retire till the right spot is no longer distinguishable, as occurs when its image falls upon the centre of the optic nerve. Picard varied this experiment, by placing an object between the eye and the spot, so that it appeared double, and one image of it covered one spot completely when one eye was closed.

Mr. C. Wheatstone places two wafers upon a table, and fixing one eye upon the opposite wafer, and closing the other, moves the other wafer gradually away till it ceases to be seen: on being removed still further, it comes into view again.

(G) Although we certainly use both eyes to look generally at objects before us (those on each side can of course be seen by the eye of the same side only), yet when we fix our view attentively on an object, we employ but one if each eye is not of equal strength. This, at least, is my own case. If I hold up a finger, and look at distant objects, it appears double, and if I then look at it, I of course see it single, and the figure now seen is, in my case, that which was previously seen with the right eye: no difference occurs in it, if now the left eye is closed. The greater facility of threading a needle, when both are open, probably arises from the advantage of increasing the field of vision while one eye is fixed steadily upon the aperture. Some, however, who are profoundly skilled in physics, deny that the use of one eye only in attentive inspection is general.

Many recorded cases prove that one half of the retina may be paralysed, while the other half remains unaffected; and this effect may be common to both eyes, or peculiar to one. Dr. Wollaston[z] relates, that it twice occurred to him not to be able to see but on one side of the axis of vision. The first time, the left side of each eye was affected; he saw but the half of a man's face or of any object he looked at; and in attempting to read the name JOHNSON over a door, he saw only . . . . SON, the commencement of the name being totally obliterated from his view: the complaint was of short duration. About nineteen years afterwards the phenomenon recurred: this time, the right side of the eye,

[z] *Phil. Trans.* 1824.

about three degrees from the centre of the retina, was affected, and its duration was ten minutes. Two analogous cases are also mentioned by Dr. Wollaston. Desmoulins[a] states, that M. Arago has experienced this affection of vision three times: the first two times, objects situated to the right of the axis of vision were invisible; the third time he saw objects on the right only of this axis. The same author notices also the following remarkable case. In consequence of a cerebral fever, the external side of the left retina of M. de M—— became insensible: with this eye he saw only objects situate to the left of the centre of vision; and, as at the same time there was an outward deviation of the axis of this eye, through a paralysis of the nerve of the third pair, when he employed both eyes, he saw objects double; but, what was still more singular, the right eye being closed, he saw with the left eye the objects removed from twenty to twenty-five degrees to the right of their real position.

Such facts have been thought a reason for believing the decussation of the optic nerves partial, and some say that the outer portion of the tractus optici goes to the outer part of the corresponding nerves, and the inner to the inner portion of the opposite; but Magendie divided from before backwards the junction of the optic nerves, and found blindness induced.

The decussation of the optic nerves is shown by blindness of one eye being induced if the nerve on the same side is divided anteriorly to the union, and of the opposite eye if the division is made posteriorly to the union: or by destruction of an eye causing the nerve of the same side to waste as far as the union, and of the opposite side beyond the union.[b] Yet cases are on record where the wasting of the nerve in loss of sight continued throughout on the same side, but such are probably suspicious.

The thalami optici are improperly named, as they do not give origin to the optic nerves. These may be traced to the anterior corpora quadrigemina, pressure or disease of which produces blindness, and which waste if the nerve wastes.[c]

If the fifth pair, which gives sensibility to the face, is divided, the eye, nose, tongue, lose their sense of touch, — ordinary sen-

[a] *Anatomie des systèmes nerveaux des animaux à vertèbres,* t. ii. p. 673.

[b] Magendie, *Précis de Physiologie,* t. i. p. 63. sq.

[c] On the optic nerve consult Gall, *Anatomie et Physiologie,* &c. t. i. p. 113. sqq.

sibility, — in common with the skin, and are not excited by mechanical or acrid stimulus as before.[d] In this experiment, the pupil becomes greatly contracted in rabbits and guinea-pigs, and dilated in cats and dogs.[e] The retina has very little ordinary sensibility, as Magendie showed, by pricking and tearing it with little or no pain; whence contraction of the pupil does not follow the application of any stimulus excepting light. The third pair, which is a nerve of motion, supplies, in common with the fifth pair, the iris, and therefore, as Mr. H. Mayo has shown, division of it, at least in cats and pigeons, causes dilatation of the pupil, like division of the optic nerve; the dilatation arising in the former case from the cerebral influence being no longer conveyed, and in the latter from the cerebral influence being no longer excited. On stimulating the ocular end of the third pair, divided in pigeons, after removing the brain, the iris suddenly acts.[f]

[d] Magendie, l. c.

[e] Magendie, l. c. Mr. Mayo says, that, after death, in the cat and pigeon the pupil is always dilated, and in the rabbit contracted. *Outlines*, &c. p. 296.

[f] Mayo, l.c. p.294.

SECT. XVIII.

OF THE VOLUNTARY MOTIONS.

283. We have seen that the nerves perform two offices (220) — the one of feeling, the other of moving. The former we have already considered; we shall now say something with respect to the latter.

284. All the motions of the body may be divided into voluntary and involuntary.

The pulsation of the heart, and the peristaltic motion of the intestines and other viscera, are commonly adduced as instances of involuntary motion.

The action of by far the greater number of the other muscles is voluntary.

Respiration, sneezing, the tension of the membrana tympani, and the action of the cremaster, are regarded by some as belonging to the former class; by others, to the latter; and by others, as of a mixed nature.

285. If this division is narrowly examined, it will be found embarrassed by so many difficulties that the limits of each class cannot well be determined.

For, on the one hand, few functions can be termed truly involuntary, especially if we consider the connection of the imagination and passions with the will.

Again, on the other hand, there are few voluntary motions that may not be rendered involuntary by the force of habit, whose influence upon our animal motions is immense.

286. Of the latter description are those muscular motions which, although generally voluntary, take place, under certain circumstances, without the knowledge of the mind, or even in opposition to its endeavours.

Thus we wink *involuntarily*, if a friend suddenly moves his finger towards one of our eyes, though it does not come in contact: and the ring finger generally bends if we bend the little finger.

We often *unconsciously* move our limbs, even while sleeping soundly.

On the contrary, some muscles which are almost always obedient to the will, cease, under some circumstances, to be so: an instance of this exists in the difficulty which we experience in attempting to move the hand and foot of the *same* side in *different* directions, and in all those motions which, although voluntary and perfectly easy if produced separately, are found very difficult if attempted together. [a]

287. Among those motions which are supposed to be perfectly involuntary, no one is free from exception, as far as we know, excepting the spasms of the uterus during labour. [b]

With respect to the motion of the heart, we have the indubitable testimony of Drs. Baynard and Cheyne, that they saw the celebrated case of the English officer who could stop the motion of his heart and arteries at pleasure. [c] (A)

There is no question that the pulsation of the heart and arteries may be accelerated or retarded by the varied state of respiration. [d]

Rumination shows that the action of the stomach may be voluntary, and I myself once distinctly found it so, in a man who had the power of ruminating.

Although the motion of the iris is involuntary in most persons, I am credibly informed that some have been able, by a

[a] Consult Winslow, *Mém. de l'Acad. des Sciences de Paris*, 1739.

[b] That the action of even the uterus in delivery is partly voluntary in some warm-blooded animals, is shown in birds when sitting, which, if deprived of their eggs, are well known to lay others in succession.

[c] Cheyne, *Treatise on Nervous Diseases*, p. 307. sq.

[d] See Sam. Lath. Mitchill, *On the Gaseous Oxyd of Azote*, &c. New York, 1795. 12mo. p. 26.

Also Leop. Caldani, *Memorie della Accademia di Mantova*, t. i. 1795. p. 118.

considerable effort, to subject it to the will, and contract the pupil in a weak light.

And the motions commonly called involuntary, which become voluntary in some particular individuals, especially if aided by attention and liveliness of imagination, are very numerous. [e]

Thus I have seen some able to produce, at any time, a spasmodic horripilation of the skin, by representing some unpleasant sensation to their imagination.

Others have had the power of exciting local sweat in the hands, &c. [f] (B)

288. This may, perhaps, be explained on the principle of sensorial reaction (56), which may be produced by imagination — a mental stimulus, as easily as by a corporeal stimulus acting upon the sensorium (52). Many phenomena accord admirably with this explanation; *v. c.* the various causes of the erection of the penis, and of the flow of saliva.

289. The voluntary motions are the distinguishing characteristics of the animal from the vegetable kingdom. For no plant has been discovered procuring for itself food by means of voluntary motion; nor any animal incapable of locomotion, or at least of procuring sustenance by the voluntary motion of individual members.

290. In ourselves, these motions afford a striking proof of the intimate harmony which subsists between the body and the mind, and is demonstrated in the rapid and various motions of the fingers of a good performer on the harp, and of the vocal organs whenever we speak. [g]

[e] See the *Rapport des Commissaires chargés par le Roi de l'examen du* Magnétisme Animal, written by J. Sylv. Bailly, a man worthy of a better fate. Paris, 1784. 4to. p. 16.

[f] See v. c. T. Bartholin, *Act. Hafniens.* 1676. vol. iv. p. 191.

[g] A person playing on the harp, dancing, and singing, at the same time, exercises about three hundred muscles at once. G. Ent, *Animadv.* in Thrustoni *diatribam*, p. 130.

NOTES.

(A) "Colonel Townshend, a gentleman of excellent natural parts, and of great honour and integrity, had for many years been afflicted with a nephritic complaint, attended with constant vomitings, which had made his life painful and miserable. During the whole time of his illness he had observed the strictest regimen, living on the softest vegetables and lightest animal foods, drinking asses' milk daily, even in the camp; and for common drink Bristol water, which, the summer before his death, he had drunk on the spot. But his illness increasing and his strength decaying, he came from Bristol to Bath in a litter, in autumn, and lay at the Bell Inn. Dr. Baynard and I were called to him, and attended him twice a day for about the space of a week, but his vomitings continuing still incessant and obstinate against all remedies, we despaired of his recovery. While he was in this condition, he sent for us early one morning; we waited on him with Mr. Skrine his apothecary; we found his senses clear and his mind calm; his nurse and several servants were about him. He had made his will and settled his affairs. He told us he had sent for us to give him some account of an odd sensation he had for some time observed and felt in himself, which was, that composing himself, he could die or expire when he pleased, and yet by an effort, or somehow, he could come to life again; which it seems he had sometimes tried before he had sent for us. We heard this with surprise; but as it was not to be accounted for from now common principles, we could hardly believe the fact as he related it, much less give any account of it; unless he should please to make the experiment before us, which we were unwilling he should do, lest in his weak condition he might carry it too far. He continued to talk very distinctly and sensibly above a quarter of an hour about this (to him) surprising sensation, and insisted so much on our seeing the trial made, that we were at last forced to comply. We all three felt his pulse first: it was distinct, though small and thready, and his heart had its usual beating. He composed himself on his back, and lay in a still posture some time; while I held his right hand, Dr. Baynard laid his hand on his heart, and Mr. Skrine held a clean looking-glass to his mouth. I found his pulse sink gradually, till at last I could not feel any by the most exact and nice touch. Dr. Baynard could not feel the least motion of his heart, nor Mr. Skrine the least soil of breath on the bright mirror he held to his mouth; then each of us by turns examined his arm, heart, and breath, but could not by the nicest scrutiny discover the least symptom of life in him. We reasoned a long time about this odd appearance as well as we could, and all of us judging it inexplicable and unaccountable; and finding he still continued in that condition, we began to conclude that he had indeed carried the experiment too far, and at last were satisfied he was actually dead, and were just ready to leave him. This continued about half an hour, by nine o'clock in the morning, in autumn. As we were going away, we observed some motion about the body, and upon examination, found his pulse and the motion of his heart gradually returning: he began to breathe gently, and speak softly: we were all astonished to the last degree at this unexpected change, and after some further conversation with him and among ourselves, went away fully satisfied as to all the particulars of this fact, but confounded and puzzled, and not able to form any rational scheme that might account for it. He afterwards called for his attorney, added a codicil to his will, settled legacies on his servants, received the sacrament, and calmly and composedly expired about five or six o'clock that evening. Next day he was opened (as he had ordered): his body was the soundest and best made I had ever seen; his lungs were fair, large, and sound; his heart big and strong, and his intestines sweet and clean; his stomach was of a due proportion, the coats sound and thick, and the villous membrane quite entire. But when we came to examine the kidneys, though the left was perfectly sound and of a just size, the right was about four times as big, distended like a blown bladder, and yielding as if full of pap; he having often passed a wheyish liquor after his urine, during his illness. Upon opening this kidney, we found it quite full of a white chalky matter, like plaster of Paris, and all the fleshy substance dissolved and worn away, by what I called a nephritic cancer. This had been the source of all his misery; and the symptomatic vomitings from the irritation on the consentient nerves, had quite starved and worn him down. I have narrated the facts, as I saw and observed them, deliberately and distinctly, and shall leave to the philosophic reader to make what inferences he thinks fit; the truth of the material circumstances I will warrant."

(B) Those muscles, I conceive, are called voluntary, which we have ordinarily the power of directly contracting: those involuntary, which we have not ordinarily the power of directly contracting. These two definitions appear to me unexceptionable.

The latter does not contradict what is unquestionably true, — that we can indirectly affect involuntary muscles, as the heart or stomach, by thinking of certain objects, and thus exciting certain emotions; nor does the former contradict another truth, — that voluntary muscles often contract without or against our will. And this leads me to remark, that the respiratory muscles deserve the epithet voluntary as much as any in the body, for we directly contract them:[h] we feel an uneasy sensation in the chest from the retardation which occurs to the blood, and we inspire to remove it; the uneasiness being removed, our effort ceases, and expiration spontaneously ensues. It is true that respiration continues while we are asleep, and that the uneasiness is so great that we are forced to inspire. But the same is true of all voluntary muscles. If you irritate any part of a person asleep, an effort of some kind is made to withdraw from the source of uneasiness, and people turn in their sleep when uncomfortable; fowls perch on one leg, voluntarily contracting their claws before they go to sleep, and remain thus supported till they awake; somnambulists can unconsciously perform astonishing muscular movements; and while awake, we often continue walking, or performing other actions, while our minds are totally absorbed in reflecting, and give no perceptible attention to our corporeal actions. If you cause strong pain or titillation in a person awake, he will be compelled, whatever restraint he may attempt upon himself, to cry out or laugh, and to make an effort to remove it by motion of some part, as forcibly as he is compelled to remove the uneasiness in the chest by inspiration; and while history records examples of Christians and heathens so resolute as to remain motionless and silent, by the force of their faith or innocence, or their contempt for their persecutors, in the midst of fire till they were consumed; we read of suicides so determined as to have accomplished their purpose by merely holding their breath, when deprived of access to instruments of destruction.[i]

[h] This is the opinion of Haller, and ably defended by him, *El. Physiol.* t. iii. lib. viii. § 18.

[i] "Servus barbarus, cum vehementi ira concitatus, mortem sibi consciscere decrevisset, prostratus humi, respirationeque cohibitâ, longo tempore immobilis

erat; postea vero paululum volutatus, hoc pacto mortuus est." Galen, *De Nat. Musc.* lib. ii. c. 6.

A robber named Coma, when taken before the consul Rupilius, is said by Valerius Maximus to have so destroyed himself. "Let others, says the historian, sharpen the sword, mix the poison, take the rope, look for precipices,"— "nihil horum Coma, sed intra pectus inclusa anima, finem sui reperit." Lib. ix. cap. xii. externa. 1.

Few can have so much determination; and, indeed, success can rarely follow this attempt at suicide, because, as soon as the brain begins to suffer, the effort must decline, and the effects cease. Still, from general or partial tenuity of the vessels of the head, such congestion may readily occur as may occasion rupture; and suicide of this kind is therefore by no means impossible. I have known the sinuses rupture under strong muscular exertions.

Dr. Georget mentions that a M. Bourdon has lately made some experiments upon himself, from which it appears that a person may commit this kind of suicide. *De la Physiologie du Système Nerveux*, &c., t.i. p.387.

SECT. XIX.

OF MUSCULAR MOTION.

291. The immediate organs of by far the greater number of our motions are the *muscles*, which form the greatest bulk among all the similar parts.

292. They abound in azote more than other similar animal parts,[a] and the departure of this principle from its combination with hydrogen and carbon that exists during health, entirely converts them, under particular morbid affections,[b] and after death,[c] into an adipocerous substance, somewhat resembling soap or spermaceti. (A)

293. The muscles are distinguished from other similar parts chiefly by two characteristic features, the one derived from their structure, the other from their singular vital powers.

294. Their fleshy structure is formed of moving fibres, *sui generis*, and of a very faint red colour, and every muscle may be resolved into fibrous bands, these into bundles of fibres, and these again into very fine fleshy fibres and fibrils.

295. Every muscle possesses a covering of cellular membrane,[d] which is so interwoven with its substance as to surround the bands, the bundles, and even each particular fibre and fibril.

[a] Sass, Dissertation quoted already at parag. 206.

[b] For instance, in Elephantiasis. Consult Ph. Gabr. Hensler, *Vom abendländischen Aussatze in Mittelalter*, p. 316.

Accurately described examples of similar changes in other affections may be found in *Hedendaagsche Letter-Oefeningen*, t. iv. P. ii. p. 45.

And in the *Mémoires de Mathématique, &c. presentés à l'Acad. des Sciences de Paris*, t. vii. p. 301.

[c] See Thouret, *Journal de Physique*, t. xxxviii. p. 255.

G. Sm. Gibbes, *Phil. Trans.* 1794. p. 169.

[d] See Ad. Murray, *De Fascia Lata.* Upsal. 1777. 4to.

296. Every part of the muscles is amply supplied with blood-vessels and nervous threads. The latter appear to deliquesce into an invisible pulp, and unite intimately with the muscular fibres: the former are so interwoven with the fibres, that the whole muscle is red, and acquires its own paleness (294) only by being washed.

297. Most muscles terminate in tendons,[e] which are fibrous[f] parts, but so different in colour, texture, elasticity, &c., as to be readily distinguished from muscles: thus disproving the opinion of some, — that the tendinous fibres originate from the muscular. This error arose chiefly from the circumstance of the muscles of infants containing a greater number of fleshy fibres, in proportion to the tendinous, than those of the adult.

298. The other exclusive character of muscles (293), is the *irritability* of Haller,[g] the notion of which, and its difference from contractility, we formerly explained (41), but shall now prosecute farther.

299. This irritability, muscular power, or vis insita or propria, is bestowed upon all muscular parts, but in very different degrees.[h]

[e] See Fourcroy, *Mémoires de l'Academie des Sciences de Paris,* 1785. p. 392.; and 1786. p. 38.

[f] Albinus, *Annotat. Academ.* l. iv. tab. v. fig. 2.

[g] I thus distinguish it, not because the luminary of the Gottingen school first discovered it, for he repeatedly bestowed praises upon the opinions entertained with regard to it by his predecessors from the time of Glisson, but because he first investigated it as it deserved, illustrated it, enlarged the knowledge of it by numerous living dissections, and demonstrated the great power and influence of the doctrine, thus remodelled, upon the animal economy. I have also another reason, viz. to distinguish it from the irritability of the truly meritorious Gaubius, who applied the same term to the morbid sensibility of the living solid.

[h] See Haller on the irritable parts of the human body, *Commentar. Soc. Sc. Gotting.* t. ii.

And *Nov. Commentar. Gotting.* t. iv.

Among innumerable other writers on the same subject, suffice it to quote the following: —

Zimmerman, *De irritabilitate.* Gott. 1751. 4to.

Oeder, on the same. Copenhagen, 1752. 4to.

300. The highest order are the hollow muscles which perform the vital and natural functions, and especially the heart (124), whose internal surface enjoys a very lively and permanent irritability.

Next to the heart follows the intestinal canal, particularly the small intestines, which, in warm-blooded animals, contract after the heart has ceased to show signs of irritability.

Next the stomach.

Then the urinary bladder, &c.

Among the other muscles, the fibres of the tongue display the greatest irritability (135), then the respiratory muscles, *v. c.* the diaphragm, the intercostals, the triangularis sterni.

Then follow the remaining muscles.

Less, but still, however, some, exists in the arteries. (128)

Also in the venous trunks contained in the thorax. (95)

Still less, if it deserve the name of irritability, in the other blood-vessels. (132)

301. Haller, the great arbitrator in the doctrine of irritability, has ascribed it improperly (40.58.sq.), we think, to some parts possessed indeed of *contractility*, but in which we have never been able to detect genuine irritability.

Such are the lacteals, glands, gall-bladder, uterus, the dartos, and the penis. (B)

And others, with no less impropriety, bestow it upon the iris, the external surface of the lungs, &c. in which it no more exists than in the cellular membrane and those parts which are composed of it,—the common integuments, membranes of the brain, pleura, peritonæum, periosteum, medullary membrane, tendons, aponeuroses, &c. or in the proper parenchyma of the viscera, (20)—of the liver, spleen, kidneys, secundines, the brain, and the rest of the nervous system,

---

J. Eberh. Andreæ, on the same. (Præs. Ph. Fr. Gmelin.) Tubing. 1758. 4to.

Some others have been already mentioned.

As well as three entire Collections of Writers, parag. 210.

every one of which parts is destitute alike of muscular fibre and of what is peculiar to it, — irritability.

302. As we find muscular irritability sometimes confounded with the *contractility* of the mucous web; so, on the other hand, some eminent men, particularly in modern times, have attributed it to the *nervous energy*.[1]

Now, although we cannot deny the influence of the nerves upon the muscles, most strikingly shown of late (225) by the experiments of the celebrated Galvani and others, and although no muscular fibril, however minute, can be found absolutely destitute of nervous pulp, we are not on this account to assert that irritability is not a power *sui generis*, as clearly different from the nervous energy as from contractility. For parts not muscular are not irritable, however abundantly they may be supplied with nerves, as the corium, the numerous nervous viscera; and the muscular texture alone exhibits the genuine phenomena of irritability. So that from the force of these united arguments, to omit many others, it appears more just to assign these phenomena to the muscular fibre alone, than to ascribe them to the nerves which are common to so many other parts, but do not in these excite the faintest sign of irritability. We say nothing of many weighty arguments derived, for instance, from the facts, — that no proportion exists between the degree of irritability and the number of nerves in any part, — that one of these descriptions of vital powers is often very energetic, while the other is languid in the same individual, according to national, morbid, or more especially to sexual variety, &c. (C)

303. The nerves exert their influence upon the muscles, as *remote* or *exciting* causes of their action, but by no means as

[1] To this point chiefly relate the celebrated disputes respecting the influence of nerves upon the motion of the heart, and the modus operandi of opium upon the heart and nerves.

Consult, besides other distinguished authors already quoted,

Rob. Whytt, *Essay on the Vital and other Involuntary Motions of Animals.* Edinb. 1751. 8vo.; and more at large in his Works. ib. 1768. 4to.

J. Aug. Unzer, *Erste Gründe einer Physiologie der eigentlichen thierischen Natur thierischer Körper.* Leipzig. 1771. 8vo.

the *proximate* or *efficient*, which is the inherent irritability of the muscles.

The passions, *v. c.* act upon the sensorium, and this upon the nerves of the heart, so as to excite its irritability, which produces palpitation and other anomalous motions.

The will acts upon the sensorium, and this re-acts upon the nerves of the arm, which excite muscular motion, as remote causes: but the proximate cause is the irritability of the muscles themselves.

304. With this distinction of the two causes of muscular motion, the result of those experiments exactly correspond which have been so frequently made by dividing or tying the nerves.[k] Paralysis ensued, but irritability continued vigorous for a great length of time afterwards.

There have been cases where one limb was motionless from paralysis but retained its sensibility, while the other was insensible but still capable of motion.[l] Some persons have had great pain in paralytic parts.[m]

305. The true efficacy of the blood, so copiously afforded to muscles, (296) in promoting their action, is not clearly ascertained.

In the Stenonian experiment,[n] indeed, paralysis of the hind legs commonly follows the application of a ligature upon the abdominal aorta.[o] (D)

But, after all, we are confirmed in the opinion formerly mentioned, (125)—that the action of what are commonly called voluntary muscles, depends less than that of the heart upon the afflux of blood to the moving fibres; and, on the contrary, more than it, upon the influence of the nerves which excite their irritability.

[k] J. H. v. Brunn, *Experimenta circa Ligaturas Nervorum in vivis Animalibus instituta.* Gotting. 1753. 4to.

[l] *v.* J. Stewart, *De Systematis Nervosi Officiis.* Edinb. 8vo.

[m] C. H. Pfaff, *über Thierische Elektricität und Reizbarkeit.* Leipzig. 1795. 8vo. p. 263.

[n] Stenonis, *Elementor. Myologiæ spec.* Florent. 1667. 4to. p. 86.

[o] W. Courten, *Phil. Trans.* No. 335. p. 500.

Haller, *Comment. Soc. Sc. Gotting.* t. iv. p. 293.

306. Besides these inherent powers common to all muscles, there are some peculiar and adventitious, arising from figure, situation, &c. and answering their object with perfect accuracy.

307. From the former difference among muscles, they are in general divided into hollow and solid. The first, as we have seen, not directly subject to the will, belong more to the vital and natural functions, and are, consequently, not to be considered at present, while we are speaking of the voluntary muscles, which belong to the order of animal functions.

308. Among the second, also, there is much variety. For, not to allude to difference of size, there is great diversity in the disposition of their bands and fasciculi, the direction of their fibres, the proportion of the fleshy to the tendinous part, their course, mode of insertion, &c.

309. The greatest number are long, and their fleshy bellies terminate at each extremity in tendinous chords, inert, and destitute of irritability, and fixed to the bones, which they move in the manner of levers.

310. While a very few muscles are destitute of tendons, such as the latissimus colli, an equally small number are not inserted into bones; such are the cremaster, as we generally find it, the azygos uvulæ, most of the muscles of the eye, &c.

311. The muscles endowed with those common (298. sq.) and peculiar (306. sq.) powers, are thus prepared to perform their actions, which also may be divided into common and peculiar.

312. A property common to all muscles, and the immediate consequence of their irritability, is to become shorter, more rigid, and generally unequal, and, as it were, angular, during contraction.

To attempt, with J. and D. Bernouilli and other mathematical physicians, to reduce this diminution to a general admeasurement, is rendered impossible, by the great difference, among other causes, between the hollow and solid muscles in this respect, and between the solid muscles themselves, *v. c.* between straight muscles (such as the intercostals) and sphincters.

313. The peculiar actions of muscles (311) correspond with their peculiar powers, and, consequently, vary so much as to be referable to no general laws.

To cite one instance out of many, that action of certain muscles is peculiar and anomalous, which seldom occurs alone, but nearly always *subsequently* to, or *simultaneously* with, the action of some of a different order. Such is that of the lumbricales, when, during rapid motions of the fingers, they follow the action of other muscles of the metacarpus and fore-arm; and of the lateral recti muscles of the eyes, the adducens of either of which seldom acts, unless simultaneously with the abducens of the other eye.

The commonly received law—that a muscle during its contraction draws the more movable point of insertion to the more fixed, must be considered, as Winslow wisely remarks,[p] perfectly relative and subject to various limitations. Thus, for example, sometimes the one point, and sometimes the other, may be the more movable, accordingly as the *united* action of many different muscles may render the opposite more fixed.

And, on the other hand, although the action of the flexors is generally so much stronger than that of their antagonists—the extensors, that, when the body is at rest, the arms, fingers, &c. are a little bent, this does not so much depend upon the strength of the contraction of the flexors, as upon the voluntary relaxation of the extensors for our own relief.

314. Every muscle has, moreover, a peculiar *mechanism*,[q] adapted to the individual motions for which it is intended.

Besides the determinate figure of each, many other kinds of assistance are afforded to their peculiar motions, *v. c.* by the *bursæ mucosæ*, chiefly found among the muscles of the extremities; the annular ligaments by which some are sur-

[p] *Mém. de l'Acad. des Sc. de Paris.* 1720.

[q] P. J. Barthez, *Nouvelle Méchanique des Mouvemens de l'Homme et des Animaux.* Carcass. 1798. 4to.

rounded; the fat in which most are imbedded; the lymphatic vapour around each; and, above all, by the conformation of the skeleton, chiefly in regard to apophyses, condyles, and articulations; nay, even whole bones, *v. c.* the patella, the pisiform of the carpus, and the sesamoid bones;[r] are destined solely to facilitate the actions of certain muscles.

315. In this mode is compensated, or, at least, diminished, that inevitable loss of power which necessarily takes place from the conformation and stature of the whole system, as, from the acute angle at which some muscles are inserted, or the proximity of their insertion to the centre of motion, much of that power is lost which would have existed, if their insertion had been more remote or at a more obtuse angle.[s]

316. The human body, possessing about 450 muscles, or upwards, according to sexual or individual variety, is thus furnished with a double advantage,—with an extreme agility of motion in particular parts and throughout the whole, and with a surprising degree of strength and endurance of labour. Both these are accomplished partly by the perfection of the muscles, which, like the perfection of the bones, takes place at manhood; and partly by habit and practice, the power of the former of which in affording strength and agility to the muscles, is demonstrated in rope-dancers, leapers, runners, wrestlers, porters, savages, and the examples of ancient nations.[t]

NOTES.

(A) Muscle is essentially fibrine, but contains also albumen, gelatine, fat, salts, &c. and a peculiar substance termed osmazome,

[r] Hence, of all animals which I have dissected, the mole is supplied with the most remarkable apparatus of sesamoid bones; its anterior palmated feet, with which it digs, have many of these bones, which greatly facilitate the action of the brachial muscles.

[s] Gilb. Blane, *On Muscular Motion*, p. 51.

[t] I have treated on this point at large, in the *Medic. Biblioth.* vol. ii. p. 407.

upon which the peculiar taste and smell of soup depends, and which is a yellowish brown substance, soluble in water and in alcohol hot or cold, and not forming a jelly when concentrated.

(B) Mr. Hare affirms, that in the field of a moderately powerful microscope, a muscular fibre evidently appears made up of numerous minute tubes, each exhibiting longitudinal striæ, with transverse bands; the average diameter of each of these ultimate fibres or tubes being $\frac{1}{400}$ of an inch.[u] Under contraction, the portions between the transverse bands draw the latter nearer together, and, swelling out, seem girted by them, so that the whole fibre somewhat resembles a string of eggs. This appearance, the writer supposes, led Dr. Croon to adopt the idea that the ultimate fibre of muscle was constituted by a chain of bladders filled with fluid. In fact Mr. Bauer thinks he discovers muscular fibres to be chains of globules,[x] and Prevost and Dumas declare the same from their microscopic observations.[y] The muscular tubes are represented by Mr. Hare as filled with a matter which causes them to appear solid, till it is liquefied by heat: Mascagni describes the muscular fibre as a small cylinder, filled with glutinous matter.[z] The fibres of tendon are said to be really solid, of infinitely smaller diameter, and disposed in a reticulated manner. Even cellular membrane is said to consist of reticulated tubular fibres, $\frac{1}{1000}$ of an inch in diameter on the average, and exhibiting transverse contractions.[a] Fontana, by means of glasses of moderate powers, found tendon to be composed of bands, which again are composed of solid spiral cylinders, of uniform size, and pursuing a tortuous course.[b] He also asserts that the primitive muscular fibre is marked by continual minute crispations and nodosities, and that it pursues a straight course, but is solid like the tendinous. Meckel and Rudolphi believe the primitive muscular fibre solid. Dr. Hodgkin found it not to consist of globules, and to be marked

[u] Thomas Hare, *A View of the Structure, Functions, and Disorders of the Stomach,* &c. p. 28. sq. 1821.

[x] *Phil. Trans.* 1818. J. F. Meckel has made careful microscopical observations, and finds the muscular no less than the nervous fibre, and the substance of the liver, kidney, spleen, &c., to be globular.

[y] *Annales de Chimie.* t. xviii.

[z] *Prodromo.* p. 97.

[a] Hare, l. c. p. 36.

[b] *Sur les Poisons.* t. ii. p. 230. sq.

by transverse lines, which he thinks distinguish muscular from all other fibres. (supra. p. 3.)

Prevost and Dumas assert, that the muscular fibres, straight while at rest, approximate each other at intervals, under contraction, so as to acquire a zigzag course ($\diagdown\diagup\diagdown\diagup\diagdown\diagup$), and shorten the distance of their two extreme points.[c] They ascertained satisfactorily, that during contraction no increase of volume is acquired. If muscles, while the fibres are straight, are stretched still more, as continually happens in the muscular coats of cavities, the subsequent shrinking to the original dimensions, is unattended by the zigzag appearance. Nervous filaments, they also assert, go perpendicularly to the muscular fibre at the very points where the angles are formed under the zigzag contraction, and yet not to terminate there or unite with the muscular fibres, but to return or anastomose with other nerves. The approximation of the nervous filaments to each other is thought to draw the muscular fibres into angles, and thus be the cause of muscular contraction. The approximation of the nervous filaments is considered an electric phenomenon. Electricity will effect it, and in whatever way it is effected, electric appearances are said always to be discoverable.

Muscular power is nowhere more displayed than in some fish. " I have seen," says Sir Gilbert Blane, " the sword of a sword-fish sticking in a plank which it had penetrated from side to side; and when it is considered that the animal was then moving through a medium even a thousand times more dense than that through which a bird cleaves its course at different heights of the atmosphere, and that this was performed in the same direction with the ship, what a conception do we form of this display of muscular power!"[d] Muscular strength is proportionably much greater in smaller animals. A flea can draw from seventy to eighty times its own weight, whereas a horse cannot draw with ease more than three times its own weight."[e]

(C) Irritability is the power of contracting upon the application of a stimulus, and ceases with life. It comprehends animal and organic contractility (see Note B. Sect. VI.), and we must suppose the lacteals, vessels of glands, gall-bladder, and dartos to be

[c] *Journal de Physiologie*, t. iii.

[d] *On Muscular Motion. Select Dissertations*, p. 281.

[e] l. c. Haller, *El. Physiol.* L. ix. S. ii.

possessed of it: the uterus will hereafter be shewn to have muscular fibres, according to many anatomists, and their existence will be rendered probable in the corpora cavernosa of the human penis.[f]

(D) This paralysis does not show the irritability of the muscles to be impaired; they would doubtless contract immediately after the experiment, upon the application of a stimulus, as readily as they do after apoplexy. In torpid brutes, after division of the nerves and removal of the brain, cold and warmth destroy and restore the irritability of muscles, as usual. The ligatures act immediately by depriving the nerves of the power of stimulating them; for a supply of arterial blood is necessary to the functions of the nervous system,[g] and the ligature of the abdominal aorta, practised by Haller, cuts off this from the lower part of the spinal marrow and what originate from it, — the nerves of the hind legs. If venous blood is sent to the brain, we have seen that death ensues, and the function of any part is arrested by forcing venous blood into its arteries.[h]

Another source of paralysis must ultimately arise, — the loss of irritability from the want of circulation in the muscle.

[f] Mr. Shaw has written a paper against the muscularity of the urethra. *Med. Chir. Trans.* vol. x.

[g] Le Gallois, *Sur le Principe de la Vie.*

[h] Bichat, *Recherches Physiologiques.*

SECT. XX.

OF SLEEP.

317. The faculties both of feeling and motion, possessed by the nervous system whose history we have thus pursued, are so fatigued by their exertions in the day, that rest is necessary during the night to recruit them by means of *sleep*[a] —the image of death.

318. Sleep is a completely periodical function, by which the intercourse of the mind and body is suspended, and whose phenomena, now to be traced, correspond, if any do, with the supposition of a nervous fluid.

319. Besides other precursors of sleep, may be enumerated a gradually increasing dulness of the external senses, and a relaxation of most, especially of the long, voluntary muscles; a congestion of venous blood about the heart, and relief afforded by yawning to the uneasy sensation thus produced; lastly, a curious kind of short delirium at the moment when sleep is all but present.[b]

320. The phenomena of sleep amount to this,—that the animal functions are suspended, and all the rest proceed more slowly and inactively. For the pulse is slower, the animal heat, cæteris paribus, somewhat diminished, perspiration more sparing, digestion imperfect, and nearly all the excretions

[a] Consult, besides authors hereafter to be recommended, Er. Darwin, *Zoonomia.* t. i. Sect. xviii.

And Wienholt, *Heilkraft des thierischen Magnetismus.* vol. ii. p. 437. sqq.

Fr. Aug. Ammon, *Commentatio præmio regio ornata de somni vigiliarumque statu morboso.* Gott. 1820. 4to.

C. Fr. Heusinger, *De variis somni vigiliarumque conditionibus morbosis.* Isenac. 1820. 8vo.

[b] De Pauw has some singular observations upon it in his *Recherches sur les Egyptiens et les Chinois.* t. ii. p. 159.

(except that of the semen, and this, indeed, is rather unusual) suppressed. (A)

321. The *remote* causes of sleep are evident.[c] To say nothing of narcotics, it is induced by the expenditure of the animal powers from previous fatigue or watchfulness, also by habit, and by darkness, silence, rest, &c. which acquire their somniferous powers in some measure from habit; by mild, continued, and uniform impressions upon certain senses, *v. c.* the murmur of a rivulet or the view of a field of standing corn agitated by the wind, (B) a previous meal, intense cold applied to the surface, and other modes of deriving blood from the head, as pediluvia, clysters, profuse hemorrhages, &c.

322. These remote causes may induce the *proximate* cause, which, upon mature consideration, we think probably consists in a diminished or impeded flow of oxygenated (arterial) blood to the brain; for that fluid is of the highest importance during the waking state, to the re-action of the sensorium upon the functions of the senses and upon the voluntary motions.[d]

The influx of blood is diminished by its derivation from

[c] Although the lethargic winter torpor of the Alpine marmot, the cricetum, and many other mammalia brutes, differs importantly from the periodical nocturnal sleep now spoken of, modern observations respecting this wonderful torpor have shown, that, in their phenomena and remote causes, both correspond and mutually elucidate each other.

Consult, for instance, Sulzer, *Naturgeschichte des Hamsters.* p. 162.

Spallanzani, *Sur la Respiration.* Geneva. 1803. 8vo.

Mangili, and C. Ul. Von Salis in the latter's and Steinmüller's *Alpina.* t. iv. 1809.

Cuvier, *Analyse des Travaux de la Classe Physique de l'Institut.* 1807.

[d] Those who wish to know and compare other opinions upon the causes of sleep, may consult

M. de Grimaud, *Mémoire sur la Nutrition.* Petersb. 1789. 4to. p. 194.

H. Nudow, *Versuch einer Theorie des Schlafs.* Köningsberg. 1791. 8vo.

Steph. Gallini at the end of his *Saggio d' Osservazioni sui nuovi progressi della Fisica del Corpo Umano.* Padua. 1792. 8vo.

Mauduit, in Fourcroy, in the *Médecine Eclairée,* &c. t. iv. p. 273.

T. Chr. Reil, *Functiones Organo Animæ Peculiares.* Hal. 1794. 8vo. p. 108.

L. H. Chr. Niemeyer, *Materialien zur Erregungstheorie.* Götting. 1800. 8vo. p. 71.

Troxler, *Versuche in der Organischen Physik.* p. 435.

Brandis, *Pathologie,* p. 534.

the brain and congestion in other parts; it is impeded by the pressure of foreign matter upon the brain, whether from serous or purulent collections, from depression of fractured bones, &c.

This diminution of, or impediment to, the flow of blood to the brain, causes a deficiency of water in the ventricles and a collapse of them, upon which that acute and profound physiologist, David Hartley, whom we have already praised, explains the various phenomena of dreams.[e]

Besides other phenomena which accord with this explanation, especially those of hybernating mammalia,[f] is a very remarkable one which I witnessed in a living person whose case was formerly mentioned, — that of the brain sinking whenever he was asleep, and swelling again with blood the moment he awoke.

This opinion is likewise strengthened by the production of continued watchfulness from congestion of blood in the head. (C)

323. The quantity of sleep depends much upon age, constitution, temperament, &c.; generally speaking, much sleep is the attendant of weakness, as we find in infants born prematurely, and in superannuated persons, and is a very frequent source of fatuity and torpor. (D)

324. We awake refreshed with sleep; and this return to life is attended by the same phenomena as the approach of sleep, — by gaping, to which is generally associated stretching, by some degree of dulness of the senses, &c.

325. The causes of waking correspond with those of going to sleep.

The proximate is the more free return of blood to the head.

The remote are (besides the power of custom, which is in this respect very great) various stimuli applied to the external or internal senses, either immediately affecting the nervous

[e] *Observ. on Man,* vol. i. p. 48.

[f] *v. c.* Of the alpine marmot, of which Mangili treats in Reil's *Archiv.* vol. viii. p. 466. sqq.

system, as the distension of the bladder, or mediately, by the intervention of the imagination, as in dreaming.

326. *Dreams* [g] are a sporting, as it were, of the imagination, in which it recalls the ideas of objects formerly perceived, especially of objects of sight, and appears to employ and interest itself with them.

It has been disputed whether dreams are natural during health. Some believe that sleep never occurs without them, although they may escape our memory. [h] Others conceive them the consequence only of derangement in some of the abdominal viscera. [i] Very healthy adults have asserted that they never dreamt. [k]

Dreams are generally confused and irregular, but occasionally discover extraordinary marks of reason. [l]

The power of corporeal stimulants is very great in producing dreams; *v. c.* of the semen in producing lascivious trains of ideas, of excessive repletion in causing frightful appearances. There is an instance on record of a man, in whom any kind of dreams could be induced, if his friends, by gently addressing him, afforded the subject-matter. [m] This, however, appears to be a preternatural state between sleeping and waking; as does also the truly diseased case of sleep-walkers, and the very different, though morbid, affection of somnambulists seized with what is termed magnetic ecstasis.[n]

Locke and others have regarded all dreams as a species of this mixed state. (E)

[g] Schulze, *Psychische Anthropologie,* vol. i. p. 277. 2d edit.

[h] Consult Kant, *Critik der Urtheilskraft.* p. 298. and *Anthropologie.* p. 80.

[i] See F. Xav. Mezler, *Von der Schwarzgallichten Constitution,* p. 80.

[k] Consult Locke, *Essay concerning Human Understanding,* vol. i. p. 74. Lond. 1726. 8vo.

[l] See for instance what Hollman has related of himself in this particular, *Pneumatolog. Psycholog. et Theol. Natural.* Gotting. 1780. 8vo. p. 196.

[m] Beattie, *Dissertations Moral and Critical.* Lond. 1783. 4to. p. 217.

[n] G. Gottl. Richter, *De Statu Mixto somni et vigiliæ quo Dormientes multa Vigilantium munera obeunt.* Gotting. 1756. 4to.

Wienholt, l. c. vol. iii. P. i. p. 10.

NOTES.

(A) Respiration also proceeds more slowly. The lessened power of evolving heat is strikingly shown by the greater cooling power of a cool air, and the facility with which persons take cold. It is generally thought wise in this country to cover the head preparatively to a nap in the day-time. Noxious agents would appear more powerful during sleep.

(B) Gentle motion might also be mentioned as illustrative of the effect of a mild and uniform impression on another sense. A combination is of course still more effective, whence experience has taught nurses to rock and otherwise gently agitate infants while they hum them to sleep.

(C) It is certain that the supply of arterial blood to every part, and especially to the nervous system, is requisite to its functions and its life, and that in proportion to the activity of a part is the activity of its supply of arterial blood. Analogy, therefore, renders it extremely probable that, during the inactivity of sleep, the brain, having less occasion for arterial blood, has a less vigorous circulation than during the waking state; and we know that whatever diminishes the ordinary determination of blood to the brain (321), or impairs the movement of the blood through it,[o] disposes to sleep.[p] But, although this be granted, it must be

[o] As arterial blood when at rest acquires the venous character, and the slower its motion the greater is its tendency to assume this character, it is evident that in congestion of blood, by which is meant simply an unusual quantity of blood in the vessels of a part, not flowing with its usual freedom, the part affected has not its proper supply of perfectly arterial blood. Hence congestion in the head must, even from this cause alone, produce drowsiness, to say nothing of the effect of pressure on the cerebral fibres.

[p] The phenomena of hybernating animals, which grow dull on the approach of winter, and at length fall asleep, continuing so till the return of mild weather, and generally endeavouring to lose as little heat during the approaching cold as possible, by coiling themselves up and getting into holes and warm situations, covering themselves with leaves, &c. (and all the classes of animals, except birds, contain species that have the faculty of living in this state), are precisely analogous, though very different in degree, to those of common sleep. The sensibility and all the functions are lessened, the temperature becomes nearly as low as that of the surrounding medium, the circulation slow, respiration almost or quite imperceptible, and digestion suspended. This torpidity is produced by a *deficiency* of external excitants, usually by cold and want of food, and, in the language of

viewed, not as the cause, but as a circumstance, or, in fact, a consequence, of ordinary sleep. Increase the activity of an

---

Brown, is a state of direct debility, while our ordinary sleep is one of *indirect* debility, — exhaustion. No structural peculiarity is discoverable, which enables certain animals to exist in the torpid state.

Such animals at all times produce less heat, and vary more with the surrounding medium, than others, so that Dr. Edwards in an hour cooled a dormouse 36° by surrounding it with a freezing mixture, which caused a reduction of not more than 5° or 6° in adult birds and guinea-pigs exposed to it for even a longer time. (l. c. p. 154. sq.) Some which do not hybernate resemble them in this inferior power; mice, for example, which, therefore, at all ages and seasons make for themselves nests. (p. 259.) On the other hand, hybernating animals are not all equally deficient in the power of resisting the influence of surrounding low temperatures; dormice are the most so, marmots the least; so that animals which preserve their own temperature in low media, and those which readily follow the surrounding temperature, are not widely separated, but insensibly run into each other, (l. c. p. 257. sq.) to say nothing of the inferior power of the newly-born among many of the former, and among all if born before full time, and of the various degrees of this power in different adults, and in all at different seasons of the year. (See note on animal heat.) Cold produces sleep in all, and, if the sleep is indulged, death is the result in those which cannot hybernate. Those which can, become more and more torpid, by the mere continuance of the same degree of cold. A very intense degree of cold has been found actually to arouse animals in a state of torpidity, but the excitement of the functions could not continue long, and death ensued. (p. 398.) It appeared necessary that respiration should be suspended in an experiment of M. De Saissy, who, by mere cold, could not produce torpor in a marmot till he closed the lid of the vessel in which it was placed. (p. 154.) Hence, exposure to carbonic acid, hydrogen, &c., in this state, was found by Spallanzani to have no ill effect upon a torpid marmot. (*Rapports de l'Air*, t. ii. p. 207.) Yet respiration has often seemed not to cease entirely. (See Dr. Reeve, *Essay on the Torpidity of Animals.*) The blood has been found in a certain degree coagulated in torpid bats. (Hunter, *On the Blood*, p. 25.) Cold, at any time of the year, will produce the torpid state, but want of food must greatly assist in lessening the power of maintaining temperature. On the other hand, a continual good supply of food and warm temperature increases their power of evolving heat, and enables them to resist the power of cold, so that by domestication, some cease to hybernate in the winter. (l. c. p. 472.) Dr. Edwards found that the temperature of hybernating animals sinks considerably during sleep, even in summer. (p. 473.)

Fish, and other cold-blooded animals, will survive an intense torpidity. "The fish froze," says Captain Franklin, "as fast as they were taken out of the nets, and in a short time became a solid mass of ice, and by a blow or two of the hatchet were easily split open, when the intestines might be removed in one lump. If in this completely frozen state, they were thawed before the fire, they recovered their animation." "We have seen a carp recover so far as to leap organ, you increase its circulation; diminish its activity, you diminish its circulation. The alteration of circulation is usually not the cause but the consequence; necessary, indeed, to the continuance of the altered degree of activity in the organ, but not the cause. The degree of activity of any part, and the degree of its circulation, are exactly and unalterably correspondent. If the circulation through a part be mechanically increased or diminished, the sensibility and activity of the part will, doubtless, be proportionally increased or diminished. This example occurs in hemorrhage. Frequently both are affected simultaneously,—when diarrhœa renders the surface pale and cold, both the blood is sent more sparingly to it, and the energy of its vessels is diminished by the increase of energy in those of the intestines. (Sect. VI. Note B.) But in ordinary sleep, the diminished circulation appears only the consequence, for activity is always followed by inactivity. Stimulate a muscle separated from the body, it contracts, but it soon refuses to do so; after a little rest, it again contracts upon the renewal of the stimulus. The case of the brain is analogous; and when, after its daily activity,

---

about with much vigour, after it had been frozen for six-and-thirty hours." (*Journey to the Polar Sea*, p. 248.) Izaak Walton (*The Complete Angler*, p. 257.) quotes Gesner for some large breams being put into a pond which was frozen the next winter into one mass of ice so that not one could be found, and all swimming about again when the pond thawed in the spring,—a thing "almost as incredible," says the sentimental sinner, as Lord Byron calls him, "as the resurrection to an atheist."

Insects easily bear torpidity from cold. In Newfoundland, for example, Captain Buchan saw a frozen lake, which in the evening was all still and frozen over, but, as soon as the sun had dissolved the surface in the morning, was in a state of animation, owing, as appeared by close inspection, to myriads of flies let loose, while many still remained "infixed and frozen round." Ellis also mentions, that a large black mass, like coal or peat upon the hearth, dissolved, when thrown upon the fire, into a cloud of musquitoes. (*Quarterly Review*, 1821. April. p. 200.) Those insects which hybernate are not thought by Kirby and Spence (*Entom.* vol. ii. 460. sqq.) to prepare for and enter into that state solely from cold, &c., as they do so when the season comes round, although the weather be as warm as previously, and do not before this period, though the temperature chance to be as low as it usually is in the season of hybernation.

Some animals become torpid on being deprived of moisture. A common garden snail falls torpid if put in a dry place, and may be revived at any time by the application of a little water. Moisture has revived some animalcules after a torpidity of twenty-seven years. Spallanzani, *Opuscoli di Fisica animale e vegetabile.*

it falls asleep, the diminution of its circulation consequently ensues. The influence of sleep upon the cerebral circulation is shown by the head-ache and other marks of congestion which follow too much sleep. Boerhaave mentions a physician who took a fancy that sleep was the natural state of man, and so slept eighteen out of the twenty-four hours, till he died of apoplexy. The horizontal posture will not explain these ill effects, because persons with spinal disease will lie a year upon the back without them.

The notion of Hartley's is a mere hypothesis, totally unworthy of notice. Dreaming is imperfect sleep,—sleep in which some portions of the brain are more or less active, and the circulation of such portions is no doubt more active at the time than that of the rest.

(D) In some diseases of the nervous system persons may pass many days, and even entire weeks, with little or no sleep. I have also heard a man declare he never took more than three hours sleep during the most active period of his life. Sir Gilbert Blane states, that General Pichegru informed him, that, "in the course of his active campaigns, he had for a whole year not more than one hour of sleep, on an average, in twenty-four hours."[q] Sleep varies so much in intensity that a *dead* sleep of an hour may be an equal repose to an ordinary sleep of many hours. Sleep appears much more profound at the beginning than towards the end, and, I presume, because the fatigue is then greatest and gradually lessens as sleep continues. Thus transpiration, we have seen, is at first greatest, and gradually lessens as the body loses its excess of fluid, and absorption gradually lessens as the body becomes charged with fluid.

I believe that most adults require from six to eight hours sleep. The longer the waking state is protracted the greater the exhaustion, whence one advantage of early hours, which is expressed by the adage,—one hour's sleep before twelve is worth two after. If a person rises proportionally late, he certainly cannot suffer from this course, and if he suffers, it must be ascribed, provided there is no debauch in the case, to his loss of the influence of so much solar light and morning air. The occurrence of that delirium which is mentioned by Blumenbach, at the near approach of sleep, when we do not fall asleep in a

[q] *Medical Logic*, p.83. 2d edit.

moment, and of which we are sensible by slightly recovering ourselves, is a much surer sign that we are about to get to sleep than the greatest drowsiness. The circumstance of our resisting sleep as long as we can keep our eyelids open, and falling asleep, when very sleepy, the moment we allow the eye-lids to drop, is very striking, but explicable on the continuance of voluntary effort in the former case, and cessation of it in the latter.

Independently of apoplexy, we have cases of extraordinarily long sleep. A woman in Henault slept seventeen or eighteen hours a day for fifteen years.[r] Another is recorded to have slept once for forty days.[s] A man named Samuel Chilton, twenty-five years of age, at Tinsbury, near Bath, once slept for a month. In two years he slept again for seventeen days, at the beginning of which period he took food, and had evacuations, but at length his jaws fixed. When he fell asleep the barley was sowing, and when he awoke he would hardly believe he saw it reaping. At the end of a year he fell into such another sleep. His farther history is not given.[t]

(E) In sleep the action of the mind is suspended. But the degree of suspension is extremely various. In ordinary sleep the mind is sufficiently alert to feel unpleasant sensations and make an effort to remove their causes ;— whether to remove the uneasiness of impeded circulation in the lungs by breathing, or to draw away the hand when tickled. One or more faculties is often active, and one idea associates with it another, constituting dreaming; but the activity of the mind is partial, and though we are able occasionally even to reason correctly in our dreams, we are not sufficiently ourselves to discover the incompatibility of many circumstances which we fancy. In a higher degree of activity, we answer questions put to us, although often ridiculously, as our deficiency of mental power prevents us from keeping our associations in a proper train ; and we sometimes even perform a regular series of movements. Somnambulism is but imperfect and partial sleep.[u] In it persons walk and even perform a variety of other actions, without hearing or seeing, or consciousness of their situation, so that they fall over things placed in their way, or down a

[r] *Medical Observations and Inquiries,* vol. i.

[s] Plott's *Natural History of Staffordshire.*

[t] *Phil. Trans.* 1694.

[u] S   all, l. c. t. ii. p. 503. sqq.

descent. They will sometimes write excellent letters, compose good verses, and perform accurate calculations, in this state, and on being roused into consciousness know nothing of what has happened. This state generally occurs in sleep, but it occasionally seizes persons awake, and is then termed ecstasis.[x] This is by no means uncommon at the commencement or termination of epileptic or hysteric paroxysms. In the opposite morbid affection, the patient is conscious of every thing around, but unable to move, or give the least sign of life.[y]

Night-mare is a cerebral affection, imperfect sleep, a combination of frightful fancies and fear, with an unusual loss of volition, so that we cannot excite the common voluntary muscles to action and with great difficulty move the diaphragm to inspiration.

Brutes dream as well as ourselves. Dogs start and bark in their sleep.

The great feature of sleep is the deficiency of our active powers. If we have any external sensation, or if the imagination riots on, presenting trains of images to our internal senses, we reflect upon them but weakly, make great mistakes, and however well we may reason, or whatever corporeal movement we execute, the inferiority of our active powers is conspicuous.

> ——— —— "Fancy, —
> Wild work produces oft, and most in dreams,
> Ill-matching words, and deeds long past or late.[z]"

But that active power is not suspended, as Mr. Dugald Stewart maintains in his theory of dreaming,[a] the simple fact of breathing during sleep, to say nothing of the voluntary motions of the limbs and speaking, and the acute, though circumscribed, reasoning which occasionally occurs, is a sufficient proof.

By certain processes, such as passing the points of the fingers at a short distance from a person, in a direction from the face down the arms, trunk, and legs, with a degree of energy, the state of

[x] See examples in Dr. Pritchard's work on *Diseases of the Nervous System.*

[y] A remarkable example is given in the *Psychological Magazine* of a young lady thus taken for dead, and after the funeral hymns were sung, &c. discovered to be alive by a sweat breaking forth at the moment she found the lid of the coffin was about to be nailed down. See Chrichton *on Mental Derangement.*

[z] *Paradise Lost*, book v.

[a] *Elements of the Philosophy of the Human Mind.* vol. i.

somnambulism or ecstasis may actually, we are told, be induced. It is then termed *magnetic*, and the whole phenomena, *animal magnetism*. The patient becomes insensible to all around, but has the inward senses augmented as in common ecstasis,—may sing well for the first time in his life, and talk so unguardedly as to disclose secrets. The external senses become so impenetrable, that a pistol fired in the ear is not heard, nor melted wax dropped on the body felt, nor ammonia applied to the mouth or nostrils perceived, although the gentlest word of the operator (*magnetiser*) is heard and answered, water similarly treated by him (*magnetised*) tasted and found ferruginous, and the gentlest touch of him recognised. A delightful feeling of ease and lightness is experienced, the body grows warmer, and perspires freely, though sometimes anxiety, palpitation, slight convulsions and wandering pains take place. On the first attempt these occur generally without somnambulism, and it is only after many trials (and sometimes they continue fruitless), that such a state is induced. On coming out of the somnambulism, the person is unconscious of all that has occurred; but when thrown into it again, recollects the whole and converses on it. The magnetiser can put an end to this state at pleasure. Now some of this is very probable, as we often see the most extraordinary nervous symptoms induced by mental causes, and the testimony in favour of it, supported by the probability, is too numerous and respectable to be doubted.

But this is not all. We are assured that matters often go much farther; that the patient can often be so highly magnetised, not only as to taste magnetised water and recognise the magnetiser by hearing and touch, but even to perceive objects of sight by the organ of touch, so as to read a book by the epigastrum;[b] nay more, to discover a person in the next room, though a wall intervene; to see the interior structure of his own body, and describe the seat and appearance of a diseased organ, and point out the remedy, though I am not aware of any anatomical discoveries having ever been made, and presume that blood would never have been seen flowing up the cava and down the aorta, unless Harvey had first taught the circulation; and I suppose the remedies always depend upon the country and the period,—that leeches and ptisans would be called for in France, calomel in the Indies, and iodine for bron-

[b] This reminds one

"Of Rosicrusian virtuosis,
Who see with ears and hear with noses." *Hudibras.*

chocele not before Dr. Coindet had made known its virtues. Having never seen the magnetic phenomena, I have no right to pronounce judgment: but before I can believe these wonders I must see them.

The most zealous magnetist must allow that deception has frequently been detected; that women have appeared to be in so deep a magnetic sopor that they have borne sinapisms and melted wax without the least agitation of the countenance, and yet the whole has been proved an imposture. The effects of which none can doubt—Blumenbach says some are undeniable(225), —one would at once ascribe in common language to the imagination. The magnetised person is generally a weak, delicate female; the magnetiser strong and a male. Great earnestness and energy must be manifested on his part; repeated operations are required before a high degree of magnetism occurs: not the least effect is produced if the magnetiser is weak and the patient strong, nor if the patient is incredulous; while a mere look, or mere proximity, without a single manipulation, is sufficient when the full effects have been once attained on previous occasions.

Yet, to prove that there is something more than imagination, we are assured that the magnetiser can succeed though shut in a closet and the patient totally ignorant of what is intended. As collusion is very easy, I must examine this point also myself before I believe. Water, they not only say, can be magnetised so as to taste chalybeate, but inanimate bodies made conductors.

Magnetism has been successfully applied to the cure of diseases of excitability. It is said to have been discovered by Mesmer, near the end of the last century, who, knowing that the magnet was much employed as a remedy, and hearing from M. Hell, the professor of astronomy at Vienna, that he had cured himself by magnetic plates of a severe cardiaglia, opened a house for curing every disease in this way, and began to imagine the existence of an universal magnetic power, distinct from that of the common magnet, depending upon a fluid pervading all living and mineral matter, and the source of all in art and nature. To throw this fluid into persons, — to magnetise them, he manipulated as we have mentioned, and employed other processes which are now omitted. He travelled, performed many great cures, and often failed; was extolled and abused; but such results appeared as caused a commission of enquiry to be ordered by the government of France. The whole was ascribed to imagination, and the matter dropped. Of late the subject has been revived among some of the best informed physicians of Germany and France, and a commission is now sitting in Paris to enquire into it anew. Those who ascribe all to imagination, consider the agitations and prophecies of the priestess of Apollo, the ecstasies of Dervishes and Santons, and of Shakers and Quakers, and the pretended miraculous cures of all ages, from the days of Serapis of Egypt to those of the blessed Paris of Paris,[c] as only of a piece with animal magnetism, showing how strongly fear or enthusiasm will work upon the brain and all the organs; discover the expression *magnetise* in Paracelsus and Van Helmont, and adduce a passage from Plautus to show that manipulations were used in Rome to send persons to sleep. Mercury, thinking of sending a person to sleep, says,—"Quid si ego illum *tractim* tangam ut dormiat." Sosia replies, — "Servaveris, nam continuas has tres noctes pervigilavi."[d] The hypothesis of a magnetic fluid is relinquished by many of the most enlightened magnetisers.[e] They assert the phenomena only. But by means of this fluid, some believers explain why a person cannot tickle himself; why, proverbially, when a friend is near, we think of him ("talk of the devil, &c."); and why, at the moment of death, distant friends have been said to see or hear the dying who happen to be thinking intensely of them so as magnetically to influence them!

[c] Such ecstasies, &c. and miracles were worked at his tomb, that the government closed it, and forbad any more!

"De par le Roi, défense à Dieu
De faire miracle en ce lieu."

[d] *Amphitryo*, act 1.

Consult *Lettres Physiologiques et Morales sur le Magnétisme Animale.* Par J. Amedée Dupeau. Paris, 1826.

[e] A short and luminous account and defence of animal magnetism will be found in Dr. Georget's *Physiologie du Système Nerveux*, t. i. from p. 268 to 301. 1821. Drs. Hufeland, Treviranus, Oken, Kieser, Carus, &c., believe in it.

For a good and entertaining history of the magnetic phenomena as they appeared in a patient at the Hotel Dieu in 1820, see *Expériences Publiques sur le Magnétisme Animal, faites à l'Hotel Dieu de Paris.* Par J. Dupotet, 3d edit. 1826. The woman had gastritis and aortic aneurism, and is said to have described the inner surface of her stomach as raw with red pimples, and perceived a little pouch full of blood!

For a complete history, see the *Diction. des Sc. Méd.* article *Magnétisme Animale.* The writer remarks, that in some Egyptian monuments, Anubis is represented near the patient as a magnetiser, with one hand raised above the head, the other on the breast, while behind the patient another figure stands with the right hand elevated. See also Dr. Bertrand's excellent treatise *Du Magnétisme Animal*, &c. Paris, 1826. Though partly a believer, he ascribes all to imagination.

SECT. XXI.

OF FOOD AND HUNGER.

327. As sleep repairs the loss of the animal powers, so food repairs that of the natural, and supplies fresh elementary particles in the room of those which are constantly wasting.

328. We are most effectually induced to procure and take food by calls of nature, different in kind, but tending to the same end: on one hand, by the intolerable torment of hunger and thirst; and on the other, by the equally powerful allurements of appetite.

329. Some ascribe *hunger* to an uneasiness arising in the stomach from its being empty and unoccupied; others to the mutual friction of its rugæ; others not only to the stimulus of its fluids, now secreted in abundance, — of the saliva and gastric juice, but to an acrimony which they acquire when food is not taken in proper time. (A)

330. *Thirst* appears referable both to a very unpleasant dryness of the fauces, and to the particular stimulus of acrid matters, especially of salts, taken by the mouth. It may be, therefore, the consequence of excessive absorption in the cavity of the mouth, such as occurs when the mother applies her infant to the breast, or, what is not uncommon, when venesection or purging have been ordered. Violent passions frequently induce thirst. (B)

331. The necessity of obeying these stimuli is greater or less according to age, constitution, and especially according to habit, and nothing can therefore be positively affirmed respecting its urgency; but thus much is certain, that an healthy adult, in whom all the calls of nature are felt in their usual

force,[a] cannot abstain from food a whole day without great prostration of strength, nor scarcely beyond eight days without danger to life. (C)

332. Although thirst is a violent desire, drink appears not very necessary to life and health; for many warm-blooded animals, — mice, quails, parrots, &c. do not drink at all; and some individuals of the human species have lived in perfect health and strength without tasting liquids.[b] (D)

333. It has been disputed whether our *food*, by which we satisfy these stimuli, is derived more advantageously and the more consistently with nature from the animal or from the vegetable kingdom.[c]

334. Some contend that man is herbivorous, from the shape of his teeth,[d] the length of his intestines,[e] the difference between the structure of the small and large intestines, and from the cells of the colon, &c. Rousseau ingeniously urges the circumstance that woman is naturally uniparous and provided with two breasts.[f] To these arguments it may be added, that some men have ruminated, — a power peculiar to herbivorous animals, (E) and that tame vegetable feeders are easily accustomed to animal food, whereas carnivorous animals, excepting the dog, can very seldom be brought to feed on vegetables.

The arguments of those who, with Helvetius,[g] regard man as carnivorous, are derived from the conformation of his stomach, the shortness of his cœcum, &c.

[a] Consult, among innumerable writers on long fasting, James Barthol. Beccarius, *Commentar. instituti Bononiens.* t. ii. P. 1.

And Flor. J. Voltelen, *Memorab. apositiæ septennis hist.* LB. 1777. 8vo.

[b] See G. Baker, *Med. Transact. published by the Coll. of Physicians in London*, vol. ii. p. 265. sq.

[c] J. W. Neergaard, *Vergleichende Anatomie und Physiologie der Verdauungswerkzeuge der Saügethiere und Vögel.* Berlin. 1806. P. 244.

[d] Gassendi, *Letter* to J. Bapt. v. Helmont. Opera. Florence. 1727. fol. t. vi. p. 17. Al. Monro, Senr. *Essay on Comparative Anatomy*, p. 17.

[e] J. Wallis, *Phil. Trans.* No. 269.

[f] *Sur l'Origine de l'Inégalité parmi les Hommes.* p. 196. sq.

[g] *De l'Homme.* t. ii. p. 17.

335. More careful observation, however, proves that man is not destined for either kind of food alone, but for both. His teeth, particularly the molares,[h] (F) and the peculiar structure of his intestines just alluded to, (G) hold a middle rank between the same parts in the feræ and in herbivorous animals. The mode in which the condyles of the lower jaw are articulated with the temporal bones, demonstrates it in the most striking manner. (H)

336. As the human race exists in more parts of the globe than any other kind of animal, we should have been but ill provided for, if we had been destined to subsist on either description of food alone; whereas man now inhabits some countries which afford either vegetable or animal food only.

337. Man is by far the most omnivorous of all animals, capable not only of feasting on luxurious combinations derived from each kingdom, but of subsisting with health and vigour on nearly one kind of the most simple food.

Thus, to mention a very few instances, many at present live on vegetables only, as the tubera of solanum (potatoes), chesnuts, dates, &c. The first families of mankind most probably subsisted for a long period merely on fruits, roots, corn, and pulses.[i]

The nomadic Moors have scarcely any other food than gum senega.[k] (I)

The inhabitants of Kamtschatka and many other shores scarcely any other than fish.

The shepherds in the province of Caracas in South America

[h] The opinion of Broussonet is singular. He thinks the human molares closely resemble the teeth of herbivorous animals, and at the same time regards the incisores and canini as allied to those of the carnivorous tribes: and, after comparing the *number* of the molares with that of the other teeth, concludes that the quantity of vegetable food intended for man is to the quantity of animal food as 20 to 12.

But on this calculation it follows, that infants, who have four molares only in each jaw, are destined to consume a larger portion of animal food than adults, since the proportion of the molares to the other teeth is in them as 8 to 12.

[i] Consult my very dear friend Heyne, *Opuscula Academ.* vol. i. p. 366. sq.

[k] Adanson, *Mém. de l'Acad. des Sc.* de Paris. 1778. p. 26.

on the banks of the Oronoko,[l] and even the Morlachs[m] in Europe, live almost entirely on flesh.

Some barbarous nations devour raw animals. This cannot be denied to have formerly been the case with the Samojedes,[n] the Esquimaux,[o] and some tribes of South America.[p]

Other nations are no less remarkable in their drink.

The inhabitants of many intertropical islands, especially in the Pacific Ocean, can procure no sweet water, and instead of it drink the juice of cocoa-nuts.

Others take only sea-water, and innumerable similar facts clearly prove man to be omnivorous.

NOTES.

(A) If hunger arise from merely a sense of vacuity in the stomach, why should it be increased by the application of cold to the surface, and instantly by the deglutition of cold liquids, &c.?

The explanation by friction of the rugæ is equally unsatisfactory; because the friction of these, if it does really occur, cannot be greater than the friction of the stomach against its contents immediately after a meal, when the organ is in great action, but at which time hunger does not exist.

Nor can the presence of the gastric juice explain the matter: because, as every one knows, no sensation arises in any other organ, which is not excrementory, from the peculiar stimulus of its natural fluid, and I presume that this is the stimulus intended, for the mechanical stimulus, from the bulk of the gastric juice, occurs equally from the presence of food, which does not excite hunger; because if the hungry stomach is evacuated by vomiting, as in sea-sickness, the appetite is even greater than before, when

[l] Fil. Salv. Gily, *Saggio di Storia Americana.* vol. iv. p. 120.

[m] Gius. Ant. Pujati, *Reflessioni sul vitto Pitagorico.* Feltri. 1751. 4to.

[n] (De Klingstaedt) *Mém. sur les Samojedes et les Lappons.* 1762. 8vo.

[o] Curtis, *Phil. Trans.* vol. lxiv. P. ii. p. 381. 383.

[p] J. Winter in Hakluyt's *Principal Navigations of the English Nation,* vol. iii. p. 751.

the sickness has ceased; and because hunger often ceases after a time, though the gastric juice still remains in the stomach, and is probably more abundant than ever.

The supposition of an acrimony generated in the gastric juice, &c. being a cause of hunger, is absurd. The fluid would be unfit for its purposes, and would be more likely to destroy than produce appetite.

Hunger has been attributed by some to a sympathy of the stomach with a general feeling of want in the system. But hunger is removed *immediately* that a due quantity of food is swallowed,—long before the general system can have derived benefit from the meal; fowls are satisfied when their crops are filled, although their food is not even ground, *preparatorily* to digestion, till it has passed from the crop into the gizzard; and ruminating animals leave off eating before they begin to chew the substances with which they have distended their stomachs. Again, persons unable to obtain food in sufficient quantity, lessen their hunger by swallowing any unnutritious and indigestible matter. The circumstance giving rise to this opinion is the continuance of hunger, although food be taken in abundance, in cases of scirrhus pylorus and enlarged mesenteric glands. Here, it is urged, the hunger continues, because the body receives no nourishment. But, in scirrhus of the pylorus, vomiting soon follows the reception of food into the stomach, and therefore this organ is reduced to the condition in which it was previously, and the return of hunger is easily explicable. In diseases of the mesenteric glands, there is in fact no obstruction to the course of the chyle. They are found permeable (427), and the continued hunger appears rather a part of the diseased state of the chylopoietic viscera. Besides, many cases of imperfect nutrition, from various causes, occur without any increase of appetite:—and where there is an increase of appetite, the process of digestion seems to proceed with unusual rapidity, so that the stomach becomes empty sooner than in health.—In continued abstinence, although the system is daily more in want, hunger usually ceases after a few days, whether from the stomach falling into a state of relaxation, becoming distended with wind, or from other circumstances.

If hunger arose from fatigue of the stomach, it should be greatest immediately after the laborious act of digestion, and gradually decrease; but it on the contrary increases.

Were irritation the cause, hunger should be greatest when the stomach is filled with food.

On the whole, hunger may perhaps be regarded as a sensation connected with the contracted state of the stomach.

It occurs when the stomach, being empty, must be contracted; and is increased *instantaneously* by a draught of cold liquid, which cannot but contract the stomach and corrugate its inner coat; acids, bitters, and astringents, have the same effect, and from their nature they may be supposed to act in the same way. Cold air applied to the surface increases it, and, in all probability, by a similar operation, for the impression of cold upon the skin excites an attempt at evacuation in the urinary bladder, and when all other means fail to induce the intestines to expel their contents, or the uterus to contract after delivery, the affusion of cold water so frequently succeeds, that the omission of the practice in obstinate cases is highly censurable. It is diminished by heat and every thing which relaxes. Again, it ceases immediately that the stomach is filled, and thus the stomach dilated and all corrugation removed, and the more the contents of the stomach are of a nature to be absorbed or passed into the duodenum, the sooner it recurs. Distension of the stomach is universally acknowledged to be incompatible with hunger; whence the proverb, — " a *full* belly loathes the honey-comb."

The Otomacs during the periodical innundation of the rivers of South America, when the depth of the waters almost entirely prevents fishing, appease their hunger for two or three months by distending their stomach with prodigious quantities, a pound a day and upwards, of a fine, unctuous, strong-smelling, yellowish-grey clay, slightly baked, and destitute of all organic substance, oily or farinaceous.[q] The savages of New Caledonia, in the Pacific Ocean, in times of scarcity, do the same by eating a friable lapis ollaris, consisting of equal parts of magnesia and silex, with a little oxide of copper. The wolves, rein-deer, and kids of Siberia, when pressed by hunger in winter, also devour clay or friable steatites. The Kamschatkans sometimes appease their hunger by distending their stomach with saw-dust, for want of something better.

Being, in this view, a sensation connected with a local state of

[q] Humboldt, *Tableaux de la Nature*, t. i. They become so fond of it, even when well provided with sustenance, that they take a little, and are compelled to tie their children's hands to prevent them from devouring it.

the stomach, it will be affected not only by whatever affects this state, but by whatever affects also the sensibility to this state, and therefore be subject to the common laws of sensation. Hence uncivilized tribes enable themselves to traverse large tracts without food by swallowing pills containing tobacco or opium. The pain of all excessive muscular contraction is lessened by pressure; whence the uneasiness of hunger is lessened by a belt fixed tightly over the stomach, and some Northern Asiatic tribes place a band there, and lace it behind with cords drawn tighter according to the degree of the uneasiness. Thus, the state of the stomach remaining the same, hunger may diminish from the occurrence of other feelings which attract our attention more forcibly, by passions of the mind, &c.: as is exactly the case with all other sensations, even with those that are morbid. Under strong attention of the mind to pursuits of either intellect or passion, to delightful or painful sensation, all other feelings cease to be felt, although really violent; and frequently, from being unattended to, do not recur. Passions, however, and the narcotic pills of savages, may affect hunger, not only by increasing or diminishing the sensibility to the state of the stomach, but by increasing or decreasing this state — the cause of the sensation.

(B) As hunger appears to depend upon the local condition of the stomach, so does thirst more evidently upon that of the mouth and fauces. Every consideration renders it probable that thirst is the sensation of the deficiency of moisture in the parts in which it is seated. Whatever produces this, either by causing the fluids of the mouth and fauces to be secreted in small quantity or of great viscidity, or by carrying off the fluid when secreted, produces thirst; and vice versa. *To be dry* means to be thirsty, because the state is removed by directly wetting the parts, or by supplying the system with fluid that they may be moistened by their own secretions. Being a sensation, the same may be repeated in regard to it as was observed respecting hunger. Rage or terror dry up the mouth and throat and cause violent thirst. Thirst is only momentarily assuaged by wetting the mouth and throat, because they presently grow dry again. Fluids must be swallowed to be effectual, that they may be absorbed and the parts thus preserved moist by constant secretion.

(C) Hippocrates says that most of those who abstain from food for seven days, die within that period; and if they do not, and are even prevailed upon to eat and drink, that still they perish.[r] Sir William Hamilton, however, saw a girl, sixteen years of age, apparently not in bad health, who was extricated from the ruins of a house at Oppido, in which she had remained eleven days without food: an infant in her arms, but a few months old, had died on the fourth day, as the young are never so able to endure abstinence.[s] A moderate supply of water lengthens life astonishingly. Dr. Willan was called to a young gentleman who had voluntarily abstained from every thing but a little water, just flavoured with orange *juice*, for sixty days: death ensued a fortnight afterwards.[t] Redi cruelly found that of a number of starved fowls deprived of water, none lived beyond the ninth day; whereas one indulged with water lived upwards of twenty.[u] If the water is not swallowed, but imbibed by the surface or lungs, it may also prolong life. Fodéré mentions some workmen who were extricated alive at the end of fourteen days from a cold damp cavern in which they had been buried under a ruin.[x]

A hog, weighing about 160. lbs was buried in its stye under thirty feet of the chalk of Dover Cliff for 160 days. When dug out, it weighed but 40 lbs., and was extremely emaciated, clean, and white. There was neither food nor water in the stye when the chalk fell. It had nibbled the wood of the stye and eaten some loose chalk, which from the appearance of the excrement had passed more than once through the body.[y]

In abstinence equally great imbecility of mind takes place as of body; extreme emaciation and œdema of the legs present a frightful spectacle; urine may still be secreted, but the alvine discharge is greatly diminished or suppressed altogether; the pain of hunger ceases in a few days,[z] probably from relaxation of the stomach through debility. But when hunger has ceased, though no food has been taken, weakness and sinking at the pit of the stomach are still felt.

[r] *De carnibus.*

[s] *Phil. Trans.* vol. lxxiii. p. 191. sq.

[t] *Medical Communications*, vol. ii.

[u] *Osservaz. intorno agli anim. viventi.*

[x] Fodéré, *Médécine Legale* t. ii. p. 285.

[y] *Linnæan Transact.* vol. xi. See *London Med. Journ.* vol. xxxv. 1816.

[z] Among many other accounts of starvation, some of these facts may be seen in Captain Franklin's *Narrative of a Journey to the Polar Sea*, p. 465. sq. 427. London, 1823; where the dreadful force of hunger is too truly illustrated. Our

A poor diet, even of vegetable matter, sometimes gives rise to symptoms of scurvy,[a] and famine is soon attended by epidemic fever.

The torment of thirst increases until drink is procured or moisture applied to the surface or inhaled: inflammation of the mouth and throat and intense fever at length ensue.[b]

If abstinence is not forced upon the system, but is absolutely a part of disease, it may, like suspension of respiration in morbid states of insensibility,[c] and like immense doses of powerful medicines in various diseased states, be borne with wonderful indiffer-

---

countrymen devoured their old shoes, and any scraps of leather they possessed, (pp. 418. 429. 438. 479.) The putrid spinal marrow left in bones, picked clean by wolves and birds of prey, was esteemed a prize, though its acrimony excoriated the lips; the bones were also eaten up after being burnt (p. 426.); great part of a putrid deer was devoured on the spot (p. 421.); and to destroy, skin, and cut up a cow, was the work of a few minutes, after which the contents of the stomach and the raw intestines, were at once devoured and thought excellent. (p. 407.) In the siege of Jerusalem and other ancient cities, we read of women driven by hunger to devour their offspring; and Captain Franklin was assured near the Saskatchawan, that men and women were then living, who had destroyed, and fed upon the bodies of their own families, to prevent starvation in very severe seasons. (p.51.)

[a] See Sir George Baker's account of two women, in the *Transact. of the College of Physicians*, vol. ii.

[b] A horrid description of raging thirst will be found in the account of the black-hole of Calcutta. See *Annual Register*, 1758.

[c] I omitted to give an illustration of the impunity with which a long exclusion of air may be borne, when the system is in a morbid nervous state; but an example may appear to advantage by the side of similar illustrations of the deprivation of food. "The story of Ann Green," says the Rev. Mr. Derham, "executed at Oxford, Dec. 14. 1650, is still well remembered among the seniors there; she was hung by the neck near half an hour, some of her friends thumping her on the breast, others hanging with all their weight upon her legs, sometimes lifting her up, and then pulling her down again with a sudden jerk, thereby the sooner to dispatch her out of her pain, as the printed account of her informs us. After she was in her coffin, being observed to breathe, a lusty fellow stamped with all his force on her breast and stomach, to put her out of pain. But by the assistance of Dr. Peity, Dr. Willis, Dr. Bathurst, and Dr. Clark, she was again brought to life. I myself saw her, many years after, between which time, and the date of her execution, she had, as I am informed, borne several children." (*Physico-Theology*, p. 156.) Her nervous insensibility appears from another writer, who states, that "she neither remembered how the fetters were knocked off, how she went out of prison, when she was turned off the ladder, whether any psalm was sung or not, nor was she sensible of any pain that she could remember. What

ence, and this occurs chiefly among females. But the most extraordinary case that I recollect, stated upon unquestionable authority, is that of a young Scotch woman, who laboured under an anomalous nervous affection, and, excepting that on two occasions she swallowed some water, received no nourishment whatever for eight years. She passed urine enough twice a week to wet a shilling, and for three years had no intestinal evacuation.[d]

---

is most remarkable is, that she came to herself as if she had awakened out of a sleep, not recovering the use of her speech by slow degrees, but in a manner altogether, beginning to speak just where she left off on the gallows." (Plott's *History of Oxford.*)

[d] *Phil. Trans.* vol. lxvii. In a remarkable instance of imperfect abstinence during fifty years, the woman voided a little feculent matter like a piece of roll-tobacco, or a globule of sheep's dung, but once a year, and that always in March, for sixteen years. *Edinb. Med. and Phys. Essays*, vol. vi. It would be interesting to examine the changes induced in the air by the lungs and skin of such patients.

Pouteau mentions the case of one of his patients, a young lady thirteen years of age, who was affected with convulsions and insensibility at a certain period, generally every day, sometimes not quite so often, and great irritability of stomach, lived eighteen months, and grew more than two inches and a half, on syrup of capillaire and cold water. Here, the abstinence was not part of the disease, but the extraordinary state of the system enabled it to bear the abstinence. *Œuvres Posthumes*, t. i. p. 27.

Still, many cases of abstinence have been impostures and exaggerations, and I cannot illustrate this better, than by quoting the case of Eve Heigen, the Dutch prototype of our own Anne Moore of Tutbury. She contrived to deceive the world for fourteen years (from 1597 to 1611), pretending that she took no nourishment but the scent of flowers. She had no nervous derangement to render food unnecessary, yet the minister and magistrates of Meurs made trial of her for thirteen successive days without detecting her imposture. Over her picture in the Dutch original, are these lines : —

> Meurne hæc quem cernis, decies ter sexque peregit
> Annos, bis septem prorsus non vescitur annis
> Nec potat, sed sola sedit, sic pallida vitam
> Ducit, et exigui se delectat floribus horti.

Thus beautifully rendered in the English translation.

> This maid of Meurs thirty-six yeares spent,
> Fourteen of which she tooke no nourishment;
> Thus pale and wan she sits sad and alone,
> A garden 's all she loves to looke upon.

An Apologie or Declaration of the Power and Providence of God. By George Hakewill. 1635. fol.

Respecting Anne Moore, see Dr. Henderson's *Examination*, &c.

For every example of extraordinary abstinence among females, we have a counterpart in voraciousness among males. When the appetite is so great it is seldom nice, and not only all animals in all states are devoured, but glass, flints, metals, sand, wood, &c. A Frenchman named Tarare, and described by Drs. Percy and Laurent in some measure from their own observation, [e] will form a good contrast to the Scotch girl. When a lad he once swallowed a large basket of apples after some person had agreed to pay for them; and at another time a quantity of flints, corks, and similar substances. The colic frequently compelled him to apply at the Hotel Dieu; he was no sooner relieved, however, than he began his tricks again, and once was but just prevented from swallowing the surgeon's watch, with its chain and seals. In 1789 he joined the mob and obtained sufficient food without devouring for money. He was then about seventeen, weighing a hundred pounds, and would eat five-and-twenty pounds of beef a day. When the war broke out he entered into the army, and devoured his comrades' rations, as long as better supplies from other sources rendered them of little value. But when at length his comrades stood in need of them themselves, he was nearly famished, fell ill, and was admitted into the *hôpital ambulant* at Sultzer. He there ate not only a quadruple allowance, the broken food of the other patients, and the waste of the kitchen, but would swallow the poultices and any thing else that came in his way. He devoured so many dogs and cats alive that they fled at the sight of him. Large snakes he despatched with the greatest facility, and once gobbled up in a few moments all the dinner that was provided for fifteen German labourers, viz. four bowls of curd, and two enormous dishes of dough boiled in water with salt and fat. At another time, he disposed of thirty pounds of raw liver and lights in the presence of some general officers, who, finding that he could swallow a large wooden lancet case, took the partitions out, enclosed a letter in it, and made him swallow it and proceed to the enemy's quarters for the purpose of discharging it by stool, and delivering the letter to a French colonel who had fallen into the hands of the Prussians. This he contrived

[e] *Dictionnaire des Sciences Médicales*, art. Homophage; where the dissection of another polyphagus is given, whose stomach was found to have been made neither more nor less than a collection of marine stores. See also Percy's *Mémoire sur le Polyphage* in the *Journal de Médecine*. Brumaire. An. xii.

to do, enclosed the answer in it, swallowed it again, made his escape, discharged the case again from his bowels, washed it, and, presented it to Beauharnois and the other officers. Having, however, been well drubbed by the enemy, he refused any further secret service, and was readmitted into the hospital to be cured of his hunger. Being no longer a novelty, he excited less interest, and felt it necessary to have recourse to sheep-folds, poultry-yards, private kitchens, slaughter-houses, and bye places where he had to contend with dogs and wolves for their filthy food. He was detected drinking blood that had been taken from his fellow-patients, and eating bodies in the dead house. The disappearance of a young child excited strong suspicions against him, and he was at length chased away and unheard of for four years, at the end of which time he applied at the Hospice de Versailles, wasted, no longer voracious, and labouring under a purulent diarrhœa, and he soon died, aged twenty-six. The body immediately became a mass of putridity. During his life he was always offensive, hot, and in a sweat, especially at intervals. His breath rolled off like steam, and his dejections were constantly very copious and intolerably fœtid. He was of the middle height, thin, and weak.

All the abdominal viscera were found full of suppurations.

His stomach was of immense size, and this has usually been the case in persons habitually gluttonous. A polyphagous idiot opened by the same writers displayed an enormous stomach, more resembling that of a horse than of a human being: the intestines also formed several large pouches in succession, which appeared like additional stomachs. Cabrol dissected a glutton of Toulouse, and found the œsophagus terminating in an excessively large cavity, and the intestines running, without a single convolution, but with merely a gentle sygmoid flexure, to the anus. A large pylorus, or a very depending position of it, have been found in other cases. We thus learn the common causes of constitutional voraciousness, and obtain an additional reason for referring hunger to the want of distention of the stomach: — a great quantity of food is required to *fill* these stomachs. If hunger were independent of the distention of this organ, and connected solely with the want of the system, an ordinary meal would suffice where the stomach is very large, as the extraordinary quantity of food cancannot be demanded for nourishment, — when food enough for support is taken, hunger should cease. But hunger continues till the stomach is filled, and the prodigious collection in the case of Tarare, was disposed of by abundant stools, sweating, and copious pulmonary exhalation.

The large capacity of the stomach is generally ascribable to original conformation, but some account for it occasionally by repeated over-distention and the deglutition of indigestible substances, — an opinion rather improbable when we reflect that city gluttons, who give a very fair trial to the distensibility of their idol, never acquire such appetites and capaciousness of stomach as qualify them for a show. The power of deglutition may be very much increased by practice. We have all seen the Indian jugglers, and I frequently conversed with a poor man who had swallowed nineteen large clasped knives at different times, having found in a drunken fit that he could get one down his throat for a wager:[f] yet in him the appetite and capacity of stomach were not augmented. Knife and stone eaters are seen in all countries.

Some great eaters are prodigies of strength; as Milo, who killed an ox with a blow of his fist and devoured it; and the fellow mentioned in a thesis published at Wittemberg in 1757, who once, in the presence of the Senate, ate up a sheep, a sucking-pig, and sixty pounds of plums, stones and all, and could carry four men a whole league upon his shoulders.

Voraciousness is of course sometimes, like depraved appetite, as in chlorosis and pregnancy, but temporary, and referable to merely disordered function. Dr. Satterly details the case of a lad in whom, while labouring under typhus with marked inflammation in the head, the exacerbations of fever were accompanied by such hunger, that he ate every day four regular meals, each sufficient for the stoutest labourer's dinner, and many pounds of dry bread, biscuit, and fruit between them. He had no sooner finished a meal than he denied having tasted any thing,

[f] Several pieces of the knives are preserved in the Museum of Guy's Hospital, and an account of the case may be found in the *Med. Chir. Trans.* vol. xii.

There is a collection of cases of extraordinary swallowing from Galen, Vesalius, Paré, &c., in Shenkius, *Observationes Medicæ*, lib. iii.

A polyphagus at the *Jardin des Plantes*, who once ate a lion which had died there of some disease, and at last died himself of eating 8lbs of new bread, most originally conceived, being all for the belly, that animals might be classed according to their excrement, and actually made a collection of such stores, upon which he would descant most eloquently. *Dict. des Sc. Med.* Cas Rares. p. 199.

"——— cibus omnis in illo,
Causa cibi est, semperque locus fit inanis edendo,"

and would suck and bite the bed-clothes or his fingers[g] if refused more, cared nothing about the quality of what he ate, would pass six or seven large solid motions a day by means of physic, and ultimately recovered.[h] The stomach here executed its office with excessive rapidity, and was too soon empty again.

The ant-lion will exist without the smallest supply of food, apparently uninjured, for six months; though when he can get it, he will daily devour an insect of his own size. A spider has lived without food under a sealed glass for ten months, and at the end of that time appeared as vigorous as ever. Reptiles have often lived upwards of a century enclosed in trees or stones.

On the other hand, herbivorous larvæ, as caterpillars, (for insects are carnivorous, herbivorous, and omnivorous, like their superiors,) will eat twice their weight of food daily.[i]

(D) Sauvages mentions a member of the Academy of Toulouse who never thirsted, and passed whole months of the hottest summer without drinking; and a woman who passed 40 days without liquids or thirst.[k]

(E) A striking instance of this occurred at Bristol. A man twenty years of age, had, as long as he could remember, chewed his food a second time, after swallowing it. The process began in a quarter of an hour if he had taken liquid at his meal: later, if he had not. What had passed down first, always came up first. Before the second chewing his food appeared to lie heavy in the lowest part of his throat: after it, the food "passed clear away." He found the taste of the food on its return to be chewed, rather pleasanter than at first. If this faculty left him it signified sickness, and he was never well till it returned.[l]

Blumenbach has seen four examples of this kind. In two, the

[g] Ovid's account of Erisichthon is verified in many histories of voracity.

"Ipse suos artus lacero divellere morsu
Cœpit; et infelix minuendo corpus alebat. *Metam.* lib. viii.

[h] *Transactions of the Royal College of Physicians.* London. vol. v.
See also *Phil. Trans.* Papers read 1745. and Abridgment, vol. iii. p. 112.

[i] Kirby and Spence, *Entomology,* p. 398. sq.

[k] *Nosol. Method.* t. i. p. 770.
See also *Eph. Nat. Cur.* C. v. and vi. p. 30.

[l] *Phil. Trans.* Abridgment, vol. iii. p. 111.

process was compulsory; in two, it was optional. These subjects also were males, and had a real gratification in ruminating.[m]

(F) In carnivorous animals, the incisors are very large; and the molares generally of an irregular wedge form, those of the lower jaw closing in those of the upper like scissors, and being adapted for lacerating. In the herbivorous, the surface of the molares is horizontal or oblique, adapted for grinding.

(G) As the food of herbivorous animals requires more preparation before it becomes the substance of the animal, their stomach is adapted to retain it for a length of time. The œsophagus opens nearer the right extremity of the stomach, and the pylorus nearer the left, so that a blind pouch is left on either side. In the carnivorous, the reverse is the case, and the stomach cylindrical, to favour the quick passage of the food. For the same reason, the intestines in the latter, even among insects, are generally shorter, and have fewer valvulæ conniventes, and, in some instances, no cœcum.

(H) In animals which subsist on animal food, the condyles of the lower jaw are locked in an elongated glenoid cavity, and all rotatory motion thus prevented, as motion upwards and downwards is sufficient for the laceration of the food. In vegetable feeders the joint is shallow, so that a horizontal motion is allowed for grinding the food. For its nature in man, see paragraph 339.

(I) In 1750, a caravan of Abyssinians had consumed all their provisions, and would have starved but that they discovered among their merchandise a stock of gum arabic, on which alone above a thousand persons subsisted for two months.[n] Yet M. Magendie says he finds that dogs perish if fed only with gum or sugar, olive oil, butter, and similar articles, regarded as nutritious, which contain no azote.[o] But although such substances be alone unable to nourish, yet when united with others they may afford some support, for persons accustomed to a mixed diet generally grow thinner if they confine themselves to vegetable food, which is indubitably good nourishment, and even if we grant that such substances are not nutritious to dogs, they may be proper food for other species; and to render it probable even that these are not nutritious to dogs, the animals should have been gradually brought

[m] *Comparative Anatomy.* By Lawrence and Coulson. 2d edit. p. 88.

[n] Hasselquist, *Voyages and Travels in the Levant,* p. 298.

[o] *Annales de Chimie et de Physique.* vol. iii. p. 66. 1816.

to feed on them only. For animals may be brought to live on food the most opposite to what their nature inclines them, if the change is made insensibly:—Spallanzani made a pigeon live on flesh and an eagle on bread;[p] if fresh-water molusca are put at once into sea water, or sea-water molusca into fresh water, they perish; but if the change is gradually made, they live very well;[q] a spider has fed upon sulphate of zinc;[r] we have seen that the Otomacs eat little else some months of the year than large quantities of earth, and that some brutes devour earth. I may here add that not only the Otomacs are so fond of it, as, when well supplied with food, to take a little, but that many nations of the torrid zone have a propensity to geophagism. The negroes of Guinea, the Javanese, the New Caledonians, and many South American tribes, eat clay as a luxury, and the Guajeroes, on the west of Rio da la Hache, carry a little box of lime as sailors do a tobacco-box. German workmen at the mountain of Kiffhönser spread clay instead of butter on their bread, and call it *stein butter*, and find it every satisfying and easy of digestion. The Otomacs do not suffer by the practice, but in some tribes the people grow sick and thin by indulging too freely in this luxury. Africans who geophagised with impunity at home on a yellow clay, severely suffer from it in the West Indies.[s] The red-clay eaten in Java destroys the appetite and wastes the body.

It appears that matter which has never belonged to an animated system is calculated to afford nourishment to animals in some degree, but subordinately to matter which has belonged to vegetables or animals, and that it alone will in some instances support life for a time. Vegetables will indisputably live for a time with facility on such alone, but eventually they will not thrive and perfect their seed, unless animal or vegetable remains exist in the soil; whence the necessity of this kind of manure, which must have likewise been so changed by putrefaction that its carbon has formed a compound resembling the extractive principle, and thus capable of solution in water. It has been contended

[p] *Expériences sur la Digestion*, c. lxxiv. c. lxxv.

[q] *Annales de Chimie et de Physique*, vol. ii. p. 32. 1816.

[r] Thomson's *Annals of Philosophy*, vol. xii. p. 454.

[s] See also Dr. John Hunter, *Diseases of the Army in Jamaica*, p. 248 sqq.

that some animals, as fish, and that vegetables, readily subsist, growing equally with others, and perfecting their seed, on simple water, but the experiments in support of this assertion are not at all decisive.[t]

The articles of diet generally employed by every nation and class of society are much determined by the facility with which they are procured. Generally, too, animal food is preferred in cold climates and vegetable in warm ; a mixture, however, of the two is usually preferred to either exclusively, and appears better suited to our necessities. Animal food is chiefly muscle and fat, milk and eggs ; vegetable food, chiefly, seeds and roots, fruits and leaves, with more or less of the stalks. These articles, which are rendered more or less masticable or digestible by heat, are previously subjected to high temperatures in various ways; and as many saline and aromatic substances are taken, not so much for their nutritive qualities and their undoubted assistance when the stomach is weak or chiefly vegetables are eaten, as for their sapid qualities, and since the admixture of these, and the combination of various nutritive substances together, often highly increases the exquisiteness of taste and flavour, the culinary art is cultivated not only for health, but also for luxury.

The chief proximate principles of animal food are fibrine, albumen, gelatine, ozmazome, oil, and sugar; of vegetable, gluten, fecula, mucilage, oil, and sugar. My not less excellent than distinguished friend, Dr. Prout, in the paper which has just been honoured with the Copley medal of the Royal Society,[u] reduces all the articles of nourishment among the higher animals to three classes: the saccharine, oily, and albuminous. The first comprehends sugars, starches, gums, acetic acid, and some other analogous principles; the second, oils and fats, alcohol, &c.; the third, other animal matters, and vegetable gluten, so abundant in wheat. He has favoured me with the following remarks, which are chiefly an abstract from a work on digestion, commenced by him in 1823, but not yet published.

" Observing that milk, the only article actually furnished and intended by nature as food, was essentially composed of three ingredients, viz. saccharine, oily, and curdy, or albuminous

[t] Full information on this subject will be found in Dr. Thomson's *System of Chemistry*, book iv. c. 3: sect. 2.

[u] *Phil. Trans.* 1827.

matter, I was by degrees led to the conclusion that all the alimentary matters employed by man and the more perfect animals, might, in fact, be reduced to the same three general heads; hence I determined to submit them to a rigorous examination in the first place, and ascertain, if possible, their general relations and analogies. An account of the first of these classes, viz. the saccharine matters, has been just published in the *Philosophical Transactions*, and the others are in progress. The characteristic property of saccharine bodies is that they are composed simply of carbon united to oxygen and hydrogen in the proportions in which they form water; the proportions of carbon varying in different instances from about 30 to 50 per cent. The other two families consist of compound bases (of which carbon constitutes the chief element) likewise mixed with and modified by water, and the proportion of carbon in oily bodies, which stand at the extreme of the scale in this respect, varies from about 60 to 80 per cent.; hence, considering carbon as indicating the degree of nutrition, which, in some respects may be fairly done, the oils may be regarded in general as the most nutritious class of bodies; and the general conclusion from the whole is, that substances *naturally* containing less than 30 or more than 80 per cent. of carbon are not well, if at all, adapted for aliment.

" It remains to be proved whether animals can live on one of these families exclusively, but at present experiments are decidedly against this assumption, and the most probable view is, that a mixture of two at least, if not of all three of the classes of nutriment is necessary. Thus, as has been stated, *milk* is a compound of this description, and almost all the gramineous and herbaceous matters employed as food by animals, contain at least two of the three. The same is true of animal aliments, which consist, at least, of albumen and oil; in short, it is, perhaps, impossible to name a substance employed by the more perfect animals as food, which does not essentially constitute a natural compound of at least *two*, if not of all *three* of the above three great classes of alimentary matters.

" But it is in the artificial food of man that we see this great principle of mixture most strongly exemplified. He, dissatisfied with the productions spontaneously furnished by nature, culls from every source, and, by the power of his reason, or, rather, his instinct, forms in every possible manner, and under every disguise, the same great alimentary compound. This, after all his cooking and art, how much soever he may be inclined to disbelieve it, is the sole object of his labour, and the more nearly his results approach to this, the more nearly they approach perfection. Thus, from the earliest times, instinct has taught him to add oil or butter to farinaceous substances, such as bread, and which are naturally defective in this principle. The same instinct has taught him to fatten animals, with the view of procuring the oleaginous in conjunction with the albuminous principle, which compound he finally consumes, for the most part in conjunction with saccharine matter, in the form of bread or vegetables. Even in the utmost refinements of his luxury and in his choicest delicacies, the same great principle is attended to, and his sugar and flour, his eggs and butter, in all their various forms and combinations, are nothing more nor less than disguised imitations of the great alimentary prototype, *milk*, as presented to him by nature."

More or less of common salt exists in the food of all animals. It is equally desired by the greater number, and many traverse immense tracts and encounter great difficulties to obtain it. Dr. Prout, I may mention, considers it, or the muriatic acid which it affords, of the highest importance in the animal economy.

SECT. XXII.

OF MASTICATION AND DEGLUTITION.

338. The lower jaw is the chief organ of mastication, and is supplied, as well as the upper, with three orders of teeth.

With incisores, generally[a] scalpriform for the purpose of biting off small pieces, and not placed in the lower jaw, as in other mammalia, more or less horizontally, but erect, — one of the distinctive characters of the human race.

With strong conical canine teeth, by which we divide hard substances, and which in man neither project beyond the rest, nor are placed alone, but lie closely and in regular order with the others.

With molares of various sizes, adapted for grinding, and differing conspicuously from those of other mammalia, by possessing gibbous apices excessively obtuse.

339. The lower jaw is connected with the skull by a remarkable articulation, which holds a middle rank between arthrodia and ginglymus, and, being supplied with two car-

[a] I say generally: for, omitting particular examples of their obtuseness, I may remark that, in the skulls of most mummies, I have found the crown of the incisores thick and obtuse. And since the more remarkable for this variety have resembled, in their general figure and appearance, the singular and never-to-be mistaken physiognomy of the ancient Egyptians, observable in the idols, sarcophagi, and statues of ancient Egypt, it is probable that this peculiar form of the teeth, whether owing to diet or whatever else, was peculiar to the ancient Egyptians, so that it may be regarded as a national mark, or even as a characteristic by which true ancient mummies may be distinguished from those of late formation.

I have written at large on this subject in the *Philos. Trans.* 1794. P.11, p. 184.

tilaginous menisci of considerable strength, has easy motion in every direction. (A)

The digaster, assisted somewhat by the geniohyoidei and mylohyodei muscles, draws the lower jaw down, when we open the mouth.

The masseters and temporal chiefly raise it again when we bite off any thing, and are most powerfully contracted when we break hard substances.

Its lateral motions are accomplished by the internal and external pterygoid.

The latter can also draw it forwards.

340. Substances are retained, directed, and brought under the action of the teeth by the buccinator, and by the tongue, which is very flexible and changeable in form. (235)

341. During manducation, there occurs a flow of *saliva*,[b] which is a frothy fluid, consisting of a large portion of water united with some albumen, and holding in solution a small quantity of phosphate of lime — the source of the tartar of the teeth and of salivary calculi. From being constantly applied to the tongue, it is insipid, although it contains some microcosmic salt (phosphate of ammonia), as well as muriatic and, invariably, a small portion of oxalic acid. It is antiseptic[c] and very resolvent. (B)

342. The saliva flows from three orders of conglomerate glands, placed laterally and interiorally with respect to the lower jaw.

The *parotids*,[d] are the largest, and pour forth the saliva behind the middle molares of the upper jaw, through the Stenonian ducts.[e]

The *submaxillary*,[f] through the Whartonian.[g]

[b] J. Barth. Siebold, *Historia Systematis Salivalis.* Jen. 1797. 4to.

[c] Pringle, *On the Diseases of the Army.* Append. p. XLVIII. L. LXI. sq. Lond. 1765. 4to.

[d] See De Courcelles, *Icones Musculorum Capitis*, tab. I. *g. h.*

[e] Stenonis, *Observationes Anatomicæ*, p. 20.

[f] De Courcelles, l. c. tab. II. *t. t.*

[g] Wharton, *Adenographia*, p. 120.

The *sublingual,* [h] — the smallest, through the numerous Rivinian. [i]

343. The excretion of saliva, amounting, according to the arbitrary statement of Nuck,[k] to a pound in twelve hours, is augmented by stimuli and by mechanical pressure, or, if the expression may be allowed, emulsion.

The latter cause, greatly favoured by the situation of the parotids, at the articulation of the jaws, occurs when we chew hard substances, which thus become softened.

The former occurs when acrid substances are taken into the mouth, which are thus properly diluted; or arises from imagination (288), as when the mouth waters during the desire for food.

344. The mucus of the labial and buccal glands [l] and of the tongue, as well as the moisture which transudes from the soft parts of the mouth, is mixed with the saliva.

345. The mixture of these fluids with a substance which we are chewing, renders it not only a pultaceous and easily swallowed bolus, but likewise prepares it for further digestion and for assimilation.

346. The mechanism [m] of deglutition, although very complicated, and performed by the united powers of many very different parts, amounts to this. The tongue being drawn towards its root, swelling and growing rigid, receives the bolus of food upon its dorsum, which is drawn into a hollow form. The bolus is then rolled into the isthmus of the fauces, and caught with a curious and rather violent effort by the infundibulum of the pharynx, which is enlarged and in some measure drawn forward to receive it. The three constric-

[h] De Courcelles, tab. v. *g. g. g.*

[i] Rivinus, *De Dyspepsia.* Lips. 1678. 4to.
Aug. Fr. Walther, *De Lingua Humana,* ib. 1724. 4to.

[k] Nuck, *Sialographia,* p. 29. sq.

[l] De Courcelles, l. c. tab. IV. *e. e. e.*

[m] Fr. Bern. Albinus, *De Deglutitione.* LB. 1740. 4to.
P. J. Sandifort, *Deglutitionis Mechanismus.* Lugd. Batav. 1805. 4to.

tores [n] muscles of the pharynx drive it into the œsophagus. These motions are all performed in very rapid succession, and require but a short space of time.

347. Nature has provided various contrivances for opening and securing this passage.[o]

The important motion of the tongue is regulated by the os hyoides.

The smallest particle of food is prevented from entering the nostrils or Eustachian tubes, by means of the soft palate,[p] which, as well as the uvula suspended from its arch, and whose use is not clearly understood, is extended by muscles of its own, and closes those openings. [q]

The tongue protects the glottis, for the larynx at the moment of deglutition is drawn upwards and forwards, and in a manner concealed under the retracted root of the tongue and applied to the latter in such a way, that the glottis, being also constricted and protected by the epiglottis, is most securely defended from the entrance of foreign substances. (C)

348. Deglutition is facilitated by the abundance of mucus which lubricates these parts, and which is afforded not only by the tongue (237), but by the numerous sinuses [r] of the tonsils and muciparous cryptæ of the pharynx.

349. The *œsophagus*, through which the food must pass previously to entering the stomach, is a fleshy canal, narrow and very strong, mobile, dilatable, very sensible, and consisting of coats resembling, except in thickness, the coats of the other parts of the alimentary canal.[s]

[n] Eustachius, tab. XLII. fig. 4. 6.
Santorini, *Tab. Posthum.* VI. fig. 1.
B. S. Albinus, *Tab. Musculor.* XII. fig. 23, 24.

[o] J. C. Rosenmüller, *Icones Chirurgico-Anatomicæ.* Fasc. 1. Vinar. 1805. fol.

[p] Littre, *Mém. de l'Acad. des Sc. de Paris,* 1718. tab. XV.

[q] Santorini, *Tab. Posthum.* IV—VI. fig. 2. — and VII.
B. S. Albinus, *Tab. Musculor.* XII. fig. 11. 27, 28.

[r] B. S. Albinus, *Annotat. Acad.* l. III. tab. III. fig. 1. *n.*

[s] See Math. Van. Geuns, *Verhandelingen van de Maatschappye te Haarlem,* t. xi. p. 9. sq.
Jan. Bleuland, *Observ. de structura œsophagi.* LB. 1785. 4to.

The external coat is muscular, and possesses longitudinal and transverse fibres.

The middle is tendinous, lax, and more and more cellular towards each of its surfaces, by which means it is connected with the two other coats.

The interior is lined, like all the alimentary tube, with an epithelium analogous to cuticle (176), and is lubricated by a very smooth mucus.

350. This canal receives the approaching draught or bolus of food, contracts upon it, propels it downwards, and, in the case of the bolus, stuffs it down, as it were, till it passes the diaphragm and enters the stomach. (D)

NOTES.

(A) The condyles of the lower jaw are prevented from descending very deeply into the glenoid cavity, and thus being confined to vertical movements, by a cartilage which is hollow on each surface, and moveable, and permits the condyle to move from the glenoid cavity to a tubercle which stands before this, and thus to acquire still greater mobility.

(B) Saliva is composed of

Water	992.9
A peculiar animal matter	2.9
Mucus	1.4
Alkaline muriates	1.7
Lactate of soda and animal matter	0.9
Pure soda	0.2
	1000.0 [t]

What Berzelius calls mucus, Professor Thomson and Dr. Bostock regard as albumen: This mucus is insoluble in water, and, when incinerated, but not before, yields a large portion of phos-

[t] J. Berzelius, *Medico-Chirurgical Transactions*, vol. iii. p. 242.

phate of lime. The tartar of the teeth arises from its gradual decomposition upon them, and consists of

Earthy phosphates - - - -	79.0
Undecomposed mucus - - - -	12.5
Peculiar salivary matter - - - -	1.0
Animal matter soluble in muriatic acid -	7.5
	100.0[u]

According to a recent examination by Tiedemann and Gmelin, saliva, mixed with more or less mucus, consists of —

A peculiar matter termed salivary; osmazome; mucus: — all essential to its composition.

Sometimes a little albumen.

A little fatty matter, united with phosphorus.

Potass united with acetic, phosphoric, sulphuric, hydrochloric, and sulpho-cyanic acid: — all soluble salts.

A large quantity of phosphate, and a smaller of carbonate, of lime: a minute quantity of magnesia: — all three insoluble.[x]

The solid contents amount to about $\frac{1}{25}$ per cent. The alkaline properties of saliva were before ascribed to a free alkali. and that alkali was supposed to be soda. In the dog the alkali is soda, very little potass being discoverable.

(C) The glottis, when sound, may be sufficiently closed independently of the epiglottis. Dr. Magendie says that he saw two persons perfectly destitute of epiglottis who always swallowed without difficulty.[y] Targioni also met with one, and in that case neither deglutition nor speech was impaired.[z]

(D) Professor Hallé observed in a woman, the interior of whose stomach was exposed by disease, that the arrival of a bolus of food in the stomach was followed by an eversion of the mucous membrane of the œsophagus into it, as we observe in the case of the rectum when a horse has finished discharging its fæces.[a]

[u] *Die Verdauung nach Versuchen,* &c. By Fred. Tiedemann and Leopold Gmelin, Professors in the University of Heidelberg.

[x] *Précis Elémentaire,* t. ii. p. 63.

[y] Morgagni, xxviii. 13.

[z] Magendie, *Précis Elément.*

[a] Berzelius.

SECT. XXIII.

OF DIGESTION.

251. The *stomach* is the organ of digestion. It exists, what cannot be affirmed of any other viscus, in perhaps all animals without exception; and, if the importance of parts may be estimated in this way, evidently holds the first rank among our organs.

352. The human stomach[a] resembles a very large leathern bottle, is capable in the adult of containing three pints and upwards of water, and has two openings.

The superior, called *cardia*, at which the œsophagus, folded and opening obliquely, expands into the stomach, is placed towards the left side of its fundus.

The inferior, at which the right and narrower part of the stomach terminates, is called *pylorus*, and descends somewhat into the cavity of the duodenum.

353. The situation of the stomach varies accordingly as it is in a state of repletion or depletion. When empty, it is flaccid, and hangs into the cavity of the abdomen, its greater curvature inclining downwards, while the pylorus, being directed upwards, forms, by doubling, an angle with the duodenum.[b]

When full, the larger curvature is rolled forwards,[c] so that the pylorus lies more in a line with the duodenum, while the cardia, on the contrary, is folded, as it were, into an angle and closed.

[a] Eustachius, tab. x. fig. 1, 2, 3.
Ruysch, *Thes. Anat.* ii. tab. v. fig. 1.
Santorini, *Tab. Posth.* xi.

[b] Vesalius, *De c. h. Fabrica.* L. v. fig. 14, 15.

[c] Id. l. c. fig. 2.

354. The stomach is composed of four principal coats, separated by the intervention of three others, which are merely cellular.

The *external* is common to nearly all the alimentary canal, and continuous with the omentum, as we shall presently mention.

Within this, and united to it by cellular membrane, lies the *muscular* coat, which is particularly worthy of notice from being the seat of the extraordinary irritability (300) of the stomach. It consists of strata of muscular fibres,[d] commonly divided into three orders, one longitudinal and two circular (straight and oblique), but running in so many directions that no exact account can be given of their course.

The third is the chief membrane. It is usually termed *nervous*, but improperly, as it consists of condensed mucous tela, more lax on its surfaces, which are united on the one hand with the muscular and on the other with the internal villous coat. It is firm and strong, and may be regarded as the basis of the stomach.

The *interior* (besides the epithelium investing the whole alimentary canal), improperly called villous, is extremely soft, and in a manner spongy, porous, and folded into innumerable rugæ,[e] so that its surface is more extensive than that of the other coats; it exhibits very small cells,[f] somewhat similar to those larger cells which are so beautiful in the reticulum of ruminants.

Its internal surface is covered with mucus, probably secreted in the muciparous crypts which are very distinct about the pylorus.

355. The stomach is amply furnished with nerves[g] from each nervous system (214), whence its great sensibility, owing to which it is so readily affected by all kinds of stimuli, whether external, as cold, or internal, as food and its own

[d] Besides Haller, consult Bertin, *Mém. de l'Acad. des Sc. de Paris,* 1761.

[e] Ruysch, *Thes. Anat.* ii. tab. v. fig. 2, 3, 4*.

[f] See G. Fordyce, *On the Digestion of Food,* p. 12. 59. 191.

[g] Walter, *Tab. Nervor. Thorac. et Abdom.* tab. iv.

fluids, or mental; whence also the great and surprising sympathy between it and most functions of the system; to which sympathy are referable the influence of all passions upon the stomach, and of the healthy condition of the stomach upon the tranquillity of the mind.[h]

356. The abundance and utility of the blood-vessels of the stomach are no less striking. Its arteries, ramifying infinitely upon the cellular membrane and glands, secrete the *gastric juice*, which would appear to stream continually from the inner surface of the stomach.[i]

357. In its general composition this fluid is analogous to the saliva, equally antiseptic, very resolvent,[k] and capable of again dissolving the milk which it has coagulated.[l] (A)

358. Digestion is performed principally by it. The food, when properly chewed and subacted by the saliva, is dissolved[m] by the gastric fluid, and converted into the pultaceous chyme, so that most kinds of ingesta lose their specific qualities, are defended from the usual chemical changes to which they are liable, such as putridity, rancidity, &c. and acquire fresh properties preparatory to chylification.[n] (B)

359. This important function is probably assisted by various accessory circumstances. Among them, some particularly mention the *peristaltic motion*, which, being constant and undulatory, agitates and subdues the pultaceous mass of

[h] J. H. Rahn, *Mirum inter Caput et Viscera Abdominis Commercium.* Gotting. 1771. 4to.

Dit. Vegens, *De Sympathia inter Ventriculum et Caput.* LB. 1784. 4to.

Wrisberg, *Commentat. Societ. Scientiar. Gotting.* t. xvi.

[i] Ever. Home, *Phil. Trans.* 1817. p. 347. tab. xviii, xix.

[k] Ed. Stevens, *De Alimentorum Concoctione.* Edinb. 1777. 8vo.

Laz. Spallanzani, *Dissertazioni di Fisica Animale e Vegetabile.* Mödena, 1780. 8vo. vol. i.

[l] Consult Veratti, *Comment. Instituti Bononiens,* tom. vi.

[m] Even the stomach itself, when deprived of vitality, has been found acted upon, and, as it were, digested, by it. See John Hunter, *On the Digestion of the Stomach after Death. Phil. Trans.* vol. lxii.

[n] Consult Ign. Doellinger, *Grundriss der Naturlehre des menschlichen Organismus,* p. 88.

food.[o] The existence of a true peristaltic motion in the stomach during health, is, however, not quite certain; indeed, the undulatory agitation of the stomach that occurs, appears intended for the purpose of driving the thoroughly dissolved portions downwards, while those portions which are not completely subacted are repelled from the pylorus by an antiperistaltic motion.

360. The other aids commonly enumerated, are the pressure on the stomach from the alternate motion of the abdomen, and the high temperature maintained in the stomach by the quantity of blood in the neighbouring viscera and blood-vessels, which temperature was at one time supposed to be of such importance, that the word coction was synonymous with digestion.

361. To determine the time requisite for digestion is evidently impossible, if we consider how it must vary according to the quality and quantity of the ingesta, the strength of the digestive powers, and the more or less complete previous mastication.

During health, the stomach does not transmit the digestible parts of the food before they are converted into a pulp. The difference of food must therefore evidently cause a difference in the period necessary for digestion.[p] It may, however, be stated generally, that the chyme gradually passes the pylorus in between three and six hours after our meals. (C)

362. The *pylorus*[q] is an annular fold, consisting, not like the other rugæ of the stomach, of merely the villous, but also of fibres derived from the nervous and muscular, coats. All these, united, form a conoidal opening at the termination of the stomach, projecting into the duodenum, as the uterus does into the vagina, and, in a manner, embraced by it.

[o] Consult Wepfer, *Cicutæ Aquaticæ Historia et Noxæ,* in innumerable places.

[p] Consult J. Walaeus, *De motu Chyli,* p. 534. LB. 1651. 8vo.

[q] H. Palm. Leveling, *Dissert. sistens Pylorum, &c.* Argent. 1764. 4to. Reprinted in Sandifort's *Thes.* vol. iii.

NOTES.

(A) Seven grains of the inner coat of a calf's stomach were found by Dr. Young of Edinburgh to enable water poured upon it to coagulate 6857 times its weight of milk.[r]

(B) It was once imagined that fermentation, and once that trituration, was the cause of digestion, but, as neither can produce the same effects on food out of the body that occur in the stomach, these opinions fell to the ground. Besides, no signs of fermentation appear when digestion is perfect; and food, either defended from trituration by being swallowed in metallic spheres perforated to admit the gastric juice,[s] or immersed in gastric juice out of the body,[t] is readily digested.

(C) The digestive process does not go on equally through the whole mass of food, but takes place chiefly where this is in contact with the stomach, and proceeds gradually from the surface to

[r] Thomson's *System of Chemistry*, vol. iv. p. 596. ed.6. and Fordyce *On Digestion*, p.58.

[s] The Abbé Spallanzani and Dr. Stevens made such experiments upon brutes: but the latter experimented upon a man also, who was in the habit of swallowing stones and rejecting them, and who of course found no difficulty in doing the same with metallic balls.

[t] Experiments of this kind were made by Spallanzani, who procured the gastric juice by causing hungry animals to vomit, or by introducing a sponge into the stomach. But still more marked results were lately obtained in the case of a lad who had a fistulous opening from the stomach, in consequence of a wound, through which, by means of a hollow bougie and elastic bottle, gastric juice was procured at pleasure. A portion of beef was introduced into the stomach on a thread and withdrawn for comparison, at the same time that a similar portion was plunged into a phial of gastric juice, the temperature of which was kept steadily in a sand-bath at 100°, — the degree of the stomach's temperature, ascertained by the introduction of a thermometer. The portion in the phial became completely dissolved, though more slowly than that in the stomach, probably from the latter being supplied with a succession of fresh gastric juice, and freely exposed to it by motion; for the action of the fluid is only on the surface, and a portion of chicken placed in a phial of gastric juice, for a similar experiment, was more quickly acted upon if agitated. The gastric juice, when first obtained, was almost as clear as water, and its antiseptic power was shown by the solutions of beef and chicken remaining a whole autumnal month without fœtor or sour taste. *American Medical Recorder*, January, 1826. Spallanzani and others found, that if gastric juice is applied to putrescent matter, it removes the fœtor and suspends putrefaction,

the centre of the mass, so that the food at the centre is entirely different in appearance from that at the surface, and, as soon as a portion is reduced to a homogeneous consistence, it passes into the duodenum without waiting till the same change has pervaded the whole.[u]

The cardiac portion of the stomach is the chief seat of the process, and when a part of the food is tolerably digested it passes along the large curvature to the pyloric portion, where the process is completed. As the cardiac half is the great digesting portion, it is this half that is found sometimes to have been dissolved by the gastric juice after death; its contents are much more fluid than those of the pyloric half; and Dr. Philip, who by the dissection of about a hundred and thirty rabbits has been enabled to furnish the completest account of what goes on in the stomach, relates the case of a woman who had eaten and properly digested to the last, but whose stomach was ulcerated every where except at the cardiac end. Sir Everard Home says he found that fluids which had been drunk were chiefly contained in the cardiac portion, and, like many others, for upwards of a century and a half,[x] that, if the body was examined early after death, the two portions of the stomach were frequently in fact divided by a muscular contraction.[y] Dr. Haighton observed the same hour-glass contraction in a living dog, and remarked the peristaltic motion to be much more vigorous in the pyloric half.[z]

Van Helmont asserted that the food becomes sour by digestion, but this was afterwards denied, and acidity said never to happen except in cases of disorder. Sir Gilbert Blane, many years ago, however, declared that he had "satisfied himself that there is such an acid (the *gastric*) by applying the usual tests to the inner surface of the stomach of animals. This property in rumin-

[u] Dr. Prout, in Thomson's *Annals of Philosophy*, 1819.

Dr. Wilson Philip, *An Experimental Inquiry into the Laws of the Vital Functions, &c.* 1826. p.121. sqq. 3d. edit.

[x] See Dr. Munro (Tertius), *Outlines of the Anatomy of the Human Body in its sound and diseased State*, vol. ii. p. 111. 1813.

[y] *Phil. Trans.* 1808.

[z] *Transactions of the Medical Society of London*, vol. ii. 1788. In the lion, bear, &c., the stomach is usually found divided by a slight contraction at its middle, and in some animals of the mouse kind by a slight elevation of its inner coat.

ating animals," he added, "is confined to the digesting stomach."[a] Dr. Prout has discovered that the acid generated is the muriatic, both free and in combination with alkalis.[b] Tiedemann and Gmelin soon afterwards found the same thing, though without knowing, they assure us, Dr. Prout's discovery. They assert the clear ropy fluid of the stomach without food to be nearly, or entirely, destitute of acidity, while the presence of food or of the most simple stimulus to the mucous membrane, occasions it to become acid, and more so, according to the greater indigestibility of the food. The acid is very copious. They also assert the presence of acetic acid; but Dr. Prout believes this neither necessary nor ordinary, and derived from the aliment when it is observed. The general change of the aliment in the stomach appears a greater or less approach to the nature of albumen, but Dr. Prout has been unable to detect true albumen there when none has been taken.

Brutes have been the subjects of these experiments; chiefly the rabbit, horse, dog, and cat.

Besides the labours of Dr. Prout and of the professors of Heidelberg, a work has lately been published on all the subjects of chymification and chylification by MM. Leuret and Lassaigne, contradictory in many respects to the results of the others; but, knowing as I do the extreme accuracy of Dr. Prout in experimenting and deducing, and seeing that Tiedemann and Gmelin have bestowed infinite labour in repeating, varying, and extending their experiments, and have detailed all their proceedings, while the French writers merely give results and appear to have bestowed far less pains, I must be excused for merely mentioning their work.[c]

An immense number of curious facts respecting different articles of food, and many points on the subject of digestion, will be found in the German work, and a good history of opinions in the French.

In granivorous birds the food passes into the crop, and from this into a second cavity, from which it enters the gizzard, — a strong muscular receptacle, lined by a thick membrane, in which,

[a] *Transactions of a Society for the Improvement of Medical and Surgical Knowledge*, vol. ii. p. 138. sq.

[b] *Phil. Trans.* 1824.

[c] *Recherches Physiologiques et Chimiques pour servir à l'Histoire de la Digestion.* Paris, 1825.

instead of having been masticated, it is ground by means of pebbles and other hard bodies swallowed instinctively by the animal; hence true salivary glands do not exist about the mouth of birds, but abound in the abdomen, opening into the lower part of the œsophagus and into the crop and gizzard. In carnivorous birds, the gizzard is soft and smooth. The fluids of both crop and gizzard contain a free acid, according to Tiedemann and Gmelin, which is the muriatic or acetic.

Some graminivorous quadrupeds with divided hoofs have four stomachs, into the first of which the food passes when swallowed, and from this into the second. It is subsequently returned by portions into the mouth, chewed, and again swallowed, when, by a contraction of the openings of the two first stomachs, it passes over them into the third, and from this goes into the fourth. The process can be delayed at pleasure when the paunch is quite full. Some birds and insects also *ruminate*. The same chemists found the fluids of the two first stomachs alkaline, and of the third and fourth, acid. The stomachs of some insects and crustacea contain teeth. Some zoophytes are little more than a stomach: others have several openings on the surface leading by canals that unite and run to the stomach, — a structure called by Cuvier, *mouth-root*. Between the most distinct kinds of stomach we see numerous intermediate varieties. The cardiac half of the interior of the stomach of the horse, for example, is covered by cuticle, and appears merely recipient, while the pyloric half is villous and digestive, and the state of the contents in each half is, therefore, very different: a link thus existing between such stomachs as the human and the ruminating.

Vomiting cannot occur unless the stomach have the resistance of the diaphragm and abdominal muscles, or of something in their stead. Different persons have made the horrid experiment of giving an emetic to an animal, and, after the abdominal muscles were cut away, observing how fruitless were all the efforts of the stomach to reject its contents till they applied their hands in place of these muscles, when the stomach, being forced by the diaphragm against the resistance, instantly accomplished vomiting.

" In vomiting, the muscles of the cavity of the abdomen act, in which is to be included the diaphragm; so that the capacity of the abdomen is lessened, and the action of the diaphragm rather raises the ribs, and there is also an attempt to raise them by their proper muscles, to make a kind of vacuum in the thorax, that the œsophagus may be rather opened than shut, while the glottis is shut so as to let no air into the lungs. The muscles of the throat and fauces act to dilate the fauces, which is easily felt by the hand, making there a vacuum, or what is commonly called a suction." [d]

It is generally accompanied by more or less of a peculiar sensation in the stomach, called nausea: this frequently exists alone, and sometimes in a high degree; but where it increases to a certain amount, usually ends in vomiting During nausea the pulse is small, the temperature low, and the head giddy, and a large quantity of fluid is secreted in the mouth and fauces. It is excited by disgust, certain articles, pain, sympathy of the stomach with other organs not in health; by general derangement or disease of the stomach; by turning round, swinging, or the motion of a ship, and from the latter cause takes its name.

The stomach has been called the grand centre of sympathy. Its sympathies are great, but there is no reason for considering it the *centre* of sympathy. Blows upon the head or testicle, and diseases of the kidney and uterus, nay, the mere pregnant state of the latter, severe pain in any part, or a disgusting sight, will often cause vomiting. Any depressing passion deranges the stomach, but anxiety is a common source of stomach complaints, although the stomach generally bears the whole blame, and is in vain drugged and dieted, or want of exercise or great mental occupation is regarded as the cause, while the anxiety is overlooked. Pleasurable mental exertion, " constant occupation without care," must be very excessive to injure the stomach.

The stomach itself, except as far as its inner surface is very extensive and sensible, and therefore highly adapted for the influence of ingesta, appears to affect other organs, by mere sympathy, far less than it is influenced by them.

The effects of the division of the par vagum upon the lungs and stomach were mentioned at page 224; but I should remark, that Mr. Brodie found even digestion uninfluenced, if the division was made not in the neck, but close to the stomach. [e]

[d] J. Hunter, *Observations on certain Parts of the Animal Economy.*

[e] *Phil. Trans.* 1814.

SECT. XXIV.

OF THE PANCREATIC JUICE.

363. The chyme, after passing the pylorus, undergoes new and considerable changes in the duodenum[a] — a short but very remarkable portion of the intestines, before the nutrient chyle is separated. To this end, there are poured upon it various secreted fluids, the most important of which are the bile and pancreatic juice.

364. Of these we shall treat separately, beginning with the pancreatic fluid, because it is closely allied both in nature and function to the saliva and gastric juice already mentioned.

365. Although it is with difficulty procured pure from living and healthy animals, all observations made in regard to it establish its close resemblance to the saliva. At the present day, it would scarcely be worth while to mention the erroneous hypotheses of Franc. Sylvius[b] and his followers — Regn. De Graaf,[c] Flor. Schuyl,[d] and others, respecting its supposed acrimony, long since ably refuted by the celebrated Pechlin,[e] Swammerdam,[f] and Brunner,[g] unless they afforded a salutary admonition, how fatal the practice of medicine may become, if not founded on sound physiology.

[a] Laur. Claussen, *De Intestini Duodeni situ et nexu.* Lips. 1757. 4to. Reprinted in Sandifort's *Thes.* vol. iii.

And his *Tabulæ Intestini Duodeni.* LB. 1780. 4to.

[b] *De Chyli a fæcibus alvinis secretione.* LB. 1659. 4to.

[c] *De succi Pancreatici Natura et Usu.* ib. 1664. 12mo.

[d] *Pro Veteri Medicina.* ib. 1670. 12mo.

[e] *De Purgantium Medicamentorum Facultatibus.* ib. 1672. 8vo.

[f] *Observationum Anatomic. Collegii privati Amstelodamens.* P. ii. *in quibus præcipue de piscium pancreate ejusque succo agitur.* Amst. 1673. 12mo.

[g] *Experimenta nova circa pancreas.* Amst. 1683. 8vo.

366. The source of this fluid is similar to that of the saliva. It is the *pancreas*,[h] — by much the largest conglomerate gland in the system, excepting the breasts, and extremely analogous to the salivary glands in every part of its structure, even in the circumstance of its excretory ducts arising by very minute radicles and uniting into one common duct, which is denominated, from its discoverer, Wirsüngian.

This duct penetrates the tunics of the duodenum, and supplies the cavity of this intestine with a constant stillicidium of pancreatic juice.

367. The excretion of this fluid is augmented by the same causes which affect that of the saliva, — pressure and stimulus.

By the former it is emulged, whenever the stomach lies in a state of repletion upon the pancreas.

The stimuli are the fresh and crude chyme entering the duodenum, and the bile flowing through the opening common to it and the pancreatic fluid.

368. Its use is to dissolve the chyme, especially if imperfectly digested in the stomach, and at all times, by its great abundance, to assimilate the chyme more to the nature of the fluids and render it fitter for chylification.

NOTE.

Brunner, about 150 years ago, removed almost the whole pancreas from dogs, and tied and cut away portions of the duct; and they lived apparently as well as before. From one he was not contented with removing the spleen at one time and the pancreas at another, after which the poor animal *pancratice valebat;* but, to render it celebrated for experiments, he on a third occasion laid bare the intestines and wounded them for an inch and a half, sewed up the wound, made a suture in the abdominal parietes so badly that the intestines were found hanging out on the ground one

[h] Santorini, *Tab. Post.* xiii. fig. 1.

morning, purple and cold, and then allowed the animal to lick the wound into healing. He also performed the operation for aneurism in the artery of its hind leg, and paracentesis of its chest, injecting a quantity of milk into the pleura and pumping it out again. This even was not enough for the gentle Brunner; he gave the dog such a dose of opium, when it had recovered from the operation on the spleen, that it was seized with tetanus. But this also it got the better of, and lived upwards of three pleasant months with its master, "gratus mihi fuit hospes," after all these indulgencies, and was at last lost in a crowd; stolen, no doubt, because "celebris ab experimentorum multitudinem, — vivum philosophiæ experimentalis exemplum, et splene mutilus, variis cicatricibus notabilis." Brunner offered any money for it again, but to no purpose. (p. 6. 13.)

The pancreatic juice, at least in the sheep, according to Tiedemann and Gmelin, has twice as much solid contents as the saliva, and conversely a large quantity of albumen and fatty matter, with a small quantity of salivary matter and mucus; is neutral, or has only a little alkaline carbonate, and no sulpho-cyanic acid.

The use of the pancreatic juice is unknown, but Blumenbach's opinion, that it "assimilates the chyme more to the nature of the fluids," is more precisely given by Tiedemann and Gmelin, who conceive that it animalises the unazotised principles of vegetable food. It is certainly much larger proportionately in herbivorous than in carnivorous animals. They assign the same purpose to the saliva.

The quantity of the pancreatic juice cannot be accurately ascertained. It is, no doubt, produced copiously during chylification, and cannot be expected to flow readily at other times, or naturally under the torments of an experiment.

The weight of the human pancreas is about three times that of all the salivary glands together.[1]

[1] Consult Marherr, *Prælectiones in* Her. Boerhaave, *Instit. Med.* t. i. § ci.

SECT. XXV.

OF THE BILE.

369. The bile is secreted by the *liver* [a] — the most ponderous and the largest of all the viscera, especially in the fœtus, [b] in which its size is inversely as the age. The high importance of this organ is manifested, both by its immense supply of blood-vessels and their extraordinary distribution, as well as by its general existence, for it is not less common to all red-blooded animals than the heart itself. [c] (A)

370. The substance of the liver is peculiar, easily distinguished at first sight from that of other viscera, of well-known colour and delicate texture, [d] supplied with numerous nerves, [e] lymphatics (most remarkable on the surface), [f] biliferous ducts,

[a] Eustachius, tab. xi. fig. 3, 4.
Ruysch, *Thes. Anat.* ix. tab. iv.
Santorini, *Tab. Posth.* xi.

[b] J. Bleuland, *Icon hepatis fœtus octimestris.* Traj. ad Rhen. 1789. 4to.
F. L. D. Ebeling, *De Pulmonum cum hepate antagonismo.* Gott. 1806. 8vo.

[c] See Nic. Mulder's *Diss. de functione hepatis, in Disquisitione zootomica illius visceris nixa.* Lugd. Bat. 1818. 8vo.

[d] In which, however, Autenreith discovers two substances, the one medullary and the other cortical. *Archiv. für die Physiol.* t. vii. p. 299.
Consult also J. M. Mappes's Dissertation, *De penitiori hepatis humani structura,* Tub. 1817. 8vo.

[e] Walter, tab. iv.

[f] Maur. v. Reverhorst, *De motu bilis circulari ejusque morbis,* tab. i. fig. 1, 2.
Ruysch, *Ep. Problemat.* v. tab. vi.
Werner and Feller, *Descriptio vasor. lacteor. atque lymphaticor.* Fascic. i. tab. iii. et iv.; although Fr. Aug. Walter finds fault with these plates, *Annot. Academic.* p. 191. sq.
Mascagni, tab. xvii, xviii.

and, what these ducts arise from, blood-vessels,[g] which are both very numerous and in some instances very large, but of different descriptions, as we shall state particularly.

371. The first blood-vessel to be noticed is the *vena portarum*, whose dissimilarity from other veins, both in its nature and course, was formerly hinted at. (97) Its trunk is formed from the combination of most of the visceral veins belonging to the abdomen, is supported by a cellular sheath called the capsule of Glisson,[h] and, on entering the liver, is divided into branches which are subdivided more and more as they penetrate into the substance of the organ, till they become extremely minute, and spread over every part. Hence Galen compared this system to a tree whose roots were dispersed in the abdomen, and its branches fixed in the liver.[i]

372. The other kind of blood-vessels belonging to the liver, are branches of the *hepatic artery*, which arises from the cœliac, is much inferior to the vena portæ in size, and in the number of its divisions, but spreads by very minute ramifications throughout the substance of the organ.

373. The extreme divisions of these two vessels terminate in true veins, which unite into large venous trunks running to the *vena cava inferior*.

374. These extreme divisions are inconceivably minute and collected into very small glomerules,[k] which deceived Malpighi into the belief that they were glandular acini, hexagonal, hollow, and secretory.[l]

375. From these glomerules arise the *pori biliarii* — very delicate ducts, secreting the bile from the blood, and discharging it from the liver through the common hepatic duct, which is formed from their union.

376. It has been disputed whether the bile is produced from arterial or venous blood.

[g] See Haller, *Icones Anat.* Fascic. ii. tab. ii.

[h] Glisson, *Anatomia Hepatis.* p. 305. sq. 1659.

[i] *De Venarum Arteriarumque dissectione,* p. 109. Opera. Basil. 1562. Cl. i.

[k] Nest. Maximeow. Ambodick, *De Hepate.* Argent. 1775. 4to.

[l] *De viscerum structura,* p. 11. Lond. 1669.

Although the former opinion[m] is countenanced by the analogy of the other secretions which depend upon arterial blood, nevertheless more accurate investigation proves that the greater part, if not the whole, of the biliary secretion is venous.

With respect to arguments derived from analogy, the vena portæ, resembling arteries in its distribution, may likewise bear a resemblance to them in function. Besides, the liver is analogous to the lungs, in which the great pulmonary vessels are intended for their function, and the bronchial arteries for their nourishment; and if we are not greatly mistaken, the use of the hepatic artery is similar. We would, however, by no means completely deny its importance in the secretion of bile, but must regard it as inconsiderable, adventitious, and not well established. (B)

377. The *bile* flows slowly, but constantly, along the hepatic duct. The greater portion runs constantly through the ductus communis choledochus into the duodenum, but some passes from the hepatic into the *cystic duct*, and is received by the gall-bladder, where it remains for a short period, and acquires the name of *cystic bile.*[n]

378. The *gall-bladder* is an oblong sac, nearly pyriform, adheres to the concave surface of the liver, and consists of three coats.

An *exterior*, not completely covering it, derived from the peritonæum.

[m] This has lately found an advocate in Rich. Powel, *On the Bile and its Diseases.* Lond. 1801. 8vo.

[n] In the ox and other brutes there are peculiar *hepato-cystic* ducts, which convey the bile directly from the liver to the gall-bladder.

See *Observat. Anatom. Collegii privati Amstelodamens.* P. i. Ams. 1667. 12mo. p. 16. fig. 7.

Also, Perrault, *Essays de Physique*, t. i. p. 339. tab. ii.

Some have inconsiderately allowed them also in the human subject: v. c. De Haen, *Ratio medendi contin.* P. ii. p. 46. sq. tab. x. fig. 1.

Also Pitschel, *Anat. und chirurg. Anmerk.* Dresd. 1784. 8vo. tab. i.

Consult more at large, R. Forsten, *Quæstiones selectæ physiologicæ.* Lugd. Batav. 1774. 4to. p. 22.

A *middle*, called nervous, and, as in the stomach, intestines, and urinary bladder, the source of its firmness and tone.

An *interior*, [o] which may be, in some measure, compared to the inner coat of the stomach, (359) as it contains a net-work of innumerable blood-vessels, abounds in mucous glands, [p] and is marked by rugæ, [q] which occasionally have a beautifully cancellated and reticulated appearance.

379. Its cervix is conical, terminates in the cystic duct, is tortuous, and contains a few falciform valves. [r]

380. The bile which has passed into the gall-bladder is retained until, from the reclined or supine posture of the body, it flows down from it spontaneously, or is squeezed [s] out by the pressure of the neighbouring jejunum, or ileum, or of the colon when distended by fæces.

The presence of stimuli in the duodenum may derive the bile in that direction.

The great contractility of the gall-bladder, proved by experiments on living animals, and by pathological phenomena, although it has no irritability (301), probably assists the discharge of bile, especially when this fluid has, by retention, become very stimulating.

381. For the cystic bile, though very analogous to the hepatic, (377) becomes more concentrated, viscid, and bitter, by stagnation in the gall-bladder; the cause of which is, in all probability, the absorption of its more watery parts by the lymphatic vessels. [t] (C)

382. Our attention must now be turned to the bile itself—a very important fluid, respecting the nature and use of which

[o] Ruysch, *Epist. problem. quinta*. Tab. v. fig. 3.

[p] Vicq-d'Azyr, *Œuvres*, t. v. p. 343.

[q] Casp. Fr. Wolff, *Act. Acad. Scient. Petropol.* 1779. P. ii.

[r] Caldesi, *Osservaz. intorno alle Tartarughe*. Tab. ii. fig. 10.
But especially Wolff, lately commended, l. c. P. i. tab. vi.
Also Fr. Aug. Walter, l. c. tab. i.

[s] Caldani, *Institut. Physiolog.* p. 364. sq. Patav. 1778. 8vo.

[t] See Reverhorst, l. c. tab. ii. fig. 3.
Ruysch, l. c. tab. v. fig. 4.
Werner and Feller, l. c. tab. ii. fig. 5.
Mascagni, tab. xviii.

there has been more controversy for these thirty years than about any other fluid.

The cystic bile, being more perfect and better calculated for examination, will supply our observations.

383. Bile taken from a fresh adult subject is rather viscid, of a brownish green colour,[u] inodorous, and, if compared with that of brutes, scarcely bitter.

384. Its constituent parts, obtained by chemical analysis, are, besides a large proportion of water, albumen, resin, soda,[x] partly united with phosphoric, sulphuric, and muriatic acid, a small portion of phosphate of lime and iron, and a variable quantity of a remarkable and peculiar yellow matter.[y]

385. The composition of the bile varies greatly both from the proportion of its parts, particularly of the albuminous and resinous, differing under different circumstances, and also from the addition of other constituents, during morbid states, especially of adipocerous substance, which gives origin to most biliary calculi; for these consist either of it alone, or of it combined with the yellow matter just mentioned. (D)

386. The nature of the bile is not saponaceous and capable of effecting a combination between water and oils, as Boerhaave supposed, but which opinion the excellent experiments of Schröder,[z] who was formerly of this university, both confirmed and extended by other physiologists,[a] have disproved. It even decomposes a combination of those substances.[b]

[u] On the variety of colour in the bile, consult Bordenave, *Analyse de la Bile*, in the *Mém. Présentés*, &c. t. vii. p. 611. 617.

[x] Joachim Ramm, *De alcalina bilis natura*. Jen. 1786. 4to.
J. Fr. Straehl, *De bilis natura*. Gotting. 1787. 8vo.
W. M. Richter, *Experimenta circa bilis naturam*. Erlang. 1788. 4to.

[y] Thenard, *Mémoires de la Société d'Arcueil*. t. i.

[z] His *Experimenta ad veriorem cysticæ bilis indolem explorandam capta*. Sect. i. Gotting. 1764. 4to.

[a] It will be sufficient to quote a few of a large number : —
Spielmann, *De natura bilis*. Argent. 1767. 4to.
Jer. Gysb. ten. Haaf, *De bile cystica*. LB. 1772. 4to.
G. Chr. Utendörfer, *Experim. de bile*. Argent. 1774. 4to.
Dav. Willink, *Consideratio bilis*. LB. 1778. 8vo.
Seb. Goldwitz, *Neue Vers. zu einer wahren Physiol. der Galle*. Bamberg. 1785. 8vo.

[b] Marherr, *Prælect. in* BOERHAAVII *institut.* 1785. vol. i. p. 463. 479.

387. The important and various use of the bile in chylification is self-evident.

In the first place, it gradually precipitates the fæces, and separates the milky chyle from the mixed and equable pultaceous chyme, while this is passing through the tract of the small intestines, after being propelled from the stomach into the duodenum and diluted by the pancreatic juice. [c]

It separates itself into two portions, the one serous, the other resinous. The latter combines with the fæces, tinges them, and is discharged with them; the former is probably mixed with the chyle and carried back to the blood. (E)

The bile seems to act as a stimulus to the peristaltic motion [d] of the intestines.

We shall omit other less probable uses assigned to the bile, *v. c.* of exciting hunger by regurgitating into the stomach,— a circumstance which we think can hardly happen during health.

NOTES.

(A) The liver exists not only in all red-blooded animals, but in the invertebral with colourless blood, whenever a heart and blood-vessels are present. The pancreas exists in all the mammalia, birds, reptiles, and fishes.

(B) Two instances have occurred in London, of the vena portæ running, not to the liver, but immediately to the vena cava inferior. The bile must have been secreted entirely from the blood

[c] Chr. L. Werner, (Præs. Autenreith) *Experimenta circa modum, quo chymus in chylum mutatur.* Tubing. 1800. 8vo.

[d] See G. Fordyce, *On the Digestion of Food,* p. 70.

of the hepatic artery. One of these is described by Mr. Abernethy,[f] and the other is mentioned by Mr. Lawrence.[g]

We must not forget that, in the mollusca, there is no vena portæ, and the liver receives its blood from the aorta. M. Simon informs us, that, after tying the hepatic artery in pigeons, the bile was secreted as usual; but after tying the vena portæ none was produced.[h] A. Kaau found water injected into either the vena portæ or hepatic artery, exude on the surface of the liver;[i] but this might be mere imbibition.

(C) Many animals have no gall-bladder; *v. c.* the horse, goat, &c. All the carnivorous among the mammalia possess it, and all reptiles, most of which also are carnivorous; while those of the class mammalia that are destitute of it, are, with the exception of the porpoise and dolphin, vegetable feeders. Hence, Cuvier thinks that it is intended as a reservoir of bile where the animal is subject to long fasting from the uncertain supply of food. The gall-bladder is sometimes absent in the human subject. I have read of five instances of this.[k]

(D) Berzelius[l] stated, that bile contains alkali and salts in the same proportion as the blood, and that no resin exists in it, but "a peculiar matter, of a bitter and afterwards somewhat sweet taste, which possesses characters in common with the fibrin, the colouring matter, and the albumen of the blood." This forms, with an excess of acid, a perfectly resinous precipitate. What was considered albumen in the bile, Berzelius regarded as the mucus of the gall-bladder.

f *Phil. Trans.* vol. lxxxiii.

g *Medico-Chirurgic. Trans.* vol. iv. p. 174.

h *Edinburgh Journal of Medical Science*, No. I. p. 229. This effect of tying the vena portæ was long ago observed. See Sömmering, *De c. h. Fabrica*, t. vi. p. 182.

i *Perspiratio dicta Hippocrat.* 563.

k *Phil. Trans.* 1749. The subject was a woman sixty years of age. Also l. c. 1813. *Transact. of the Coll. of Phys.* vol. vi. Mr. Cooke's edition of Morgagni, and *Gazette de France*, 1826.

l *Animal Chemistry*, p. 65.

Bile contained, according to him, of

Water - - - -	907.4
Biliary matter - -	80.0
Mucus of the gall-bladder dissolved in the bile - - -	3.0
Alkalies and salts common to all secreted fluids - -	9.6
	1000.0[m]

Of the weight of alkalies and salts more than one half was pure soda.

Tiedemann and Gmelin make the bile of the ox to consist of 91.51 water, with 7.30 proximate principles, and 1.19 salts. The biliary matter, or picromel, they find a compound of resin and a sweet crystallisable substance, which, together with another, termed by them biliary asparagin, renders the resin soluble in water. They discover also ozmazome, and a new acid — the cholic, also cholesterin, gliadine, casein, the oleic, acetic, phosphoric, sulphuric, and muriatic acids, and colouring matter. The soda, they say, is not pure, but a bicarbonate, and mixed with a little potash.

(E) Fourcroy first explained the chemical operation of the bile in chylification.[n] According to Dr. Prout, during the precipitation of the chyle and the decomposition of the bile, a gaseous product is usually evolved, the mass becomes neutral, and traces *of an albuminous principle* commence, strongest at a certain distance from the pylorus, — below the point at which the bile enters the intestine, and gradually fainter in each direction. On mixing bile with chyme out of the body, a distinct precipitation takes place, and the mixture becomes neutral; but the formation of an albuminous principle is doubtful, probably from the want of the pancreatic fluid.[o]

The bitter and bilious yellow matter passes off with the fæces, while the alkali (soda) of the bile probably combines with the acid, and contributes to the formation of the chyle. The loss of the alkali which preserved the picromel in solution, causes the separation of the latter; and Dr. Prout found the distinctive

[m] *Med. Chirurg. Trans.* vol. iii. p. 241.

[n] *Système des Connoissances Chimiques,* t. x. p. 49.

[o] Dr. Prout, Thomson's *Annals of Philosophy.* 1819. p. 273.

qualities of it the more evident the further from the intestine it was examined.

It is no longer wonderful that in jaundice, so intense that no bile is seen in the fæces, and, according to Dr. Fordyce, even in artificial obstruction of the choledochus by ligature, nutrition continues, though, no doubt, less perfectly than in health. For Tiedemann and Gmelin, after tying the biliary duct, which proved on dissection to have continued impervious,[p] found the thoracic duct still containing an abundance of matter, yellowish, indeed, from the jaundice, but coagulating, and its coagulum becoming red, precisely like chyle; the small intestines had the soft flakes usually considered chyle, but thought mucus by them, and both large and small intestines contained nearly all the principles, except those of the bile, seen in sound animals; but the contents of the large intestines were exceedingly offensive. In the less satisfactory

[p] In the year 1817, Dr. James Blundell tied the choledochus several times, in the dog and rabbit, and has ever since mentioned the results in his physiological lectures. Generally the animal died of peritoneal inflammation, the bile forcing its way into the cavity among the viscera, when the ligature had produced ulceration; but when the animal did not die, the jaundice disappeared after a time, and the animal was nourished as before: the bile had found some outlet. On opening the animals, about a fortnight after the experiment, he discovered that coagulable lymph had been effused round the tied portion of the duct, so as to re-establish the canal, and the ligatures had disappeared. Dr. Blundell's well known accuracy renders all confirmation unnecessary, but I may mention, that Mr. Brodie and others have since made the same experiment with the same results.

Dr. Blundell has on record the cases of two infants, four or five months old, in whom the hepatic ducts terminated blindly; so that no bile entered the intestines, and the stools were white, like spermaceti, and the skin jaundiced. But the infants grew rapidly, and throve tolerably notwithstanding. He therefore saw that nourishment could be accomplished without the mixture of bile and chyme. Of these cases, one was examined by Mr. Luke, of the London Hospital, the other by Mr. Gaunt, of Falcon Square.

Dr. Blundell has for many years been in the habit of displaying the precipitating agency of the bile upon the chyme, by varying the mode of admixture: 1. By working chyme and bile together, when the white chyle appears in the mass, like veins in marble: 2. By enclosing chyme in black silk, and wetting a part of the external surface of this printer's ball, as it may be called, with bile; when, on rendering it tense, the liquid portion of the chyme oozes through the texture, and renders it generally blacker, but whitens it conspicuously in those spots where it meets with bile: 3. By filtering the chyme repeatedly, and then dipping into the thin strained fluid a rod with a drop of bile at its extremity, white chyle appears at the point of contact.

He found the same results in the curious hybrid experiment, of employing the bile of a dog and the chyme of a rabbit.

experiments of MM. Leuret and Lassaigne, the thoracic duct was still full of chyle.

Although the bile is seen by experimenting upon the contents of the duodenum, to cause a precipitation (Tiedemann and Gmelin deny it, but Dr. Prout has almost constantly seen it,) the chyle may thus be separated without it; but probably, Dr. Prout conceives, in less quantity and perfection.

The neutralising effect of the bile, he informs me, is evident on laying a piece of litmus paper through the pylorus, when the portion in the stomach becomes red, and that in the intestines is unaffected, or even shows alkaline agency.

The further down the intestinal contents are examined, the more do all traces of albuminous matters disappear, as well as of all the highly azotised principles of the pancreatic juice, these being supposed to convert the unazotised principles of the vegetable food into albumen: in man and carnivorous brutes no traces of either are discoverable so low down as the cæcum.

The hypothesis, that one great use of the liver was, like that of the lungs, to remove carbon from the system, with this difference, that the alteration of the capacity of the air caused a reception of caloric into the blood, in the case of the lungs, while the hepatic excretion takes place without introduction of caloric,—was, I recollect, a great favourite with me when a student, principally from the facts that a supply of venous blood — blood which has been used by the system, — runs to both liver and lungs, and to no other organs; that the higher the temperature the less carbon passed off by the lungs (less caloric being demanded by the body), and the more abundant, or more acrid, became the bile; so that bilious diseases are most prevalent in hot seasons and climates. The Heidelberg Professors have adduced many arguments to the same effect. In the fœtus, for whose temperature the mother's heat must be sufficient, the lungs perform no function, but the liver is of great size, and bile is secreted abundantly, so that the meconium accumulates considerably during the latter months of pregnancy. We shall see, indeed, that at the very time the functions of the lungs suddenly begin at birth, the liver suddenly loses much of its supply of blood. Warm-blooded animals with large lungs, living in the air, have the liver proportionally smaller than those which live partly in water: in cold-blooded animals, and reptiles, which have lungs with such large cells as but slightly to decarbonise the blood; in fish, which get rid of carbon but slowly by the gills; and in the mollusca, which decarbonise still more slowly by gills or lungs,—the liver is proportionally large. More blood flows to the liver, accordingly as the lungs are less active organs. In the mammalia and birds it receives the blood of only the stomach, intestines, spleen, and pancreas; but in the cold-blooded, of many other parts; in the tortoise, of the hind legs, pelvis, tail, and vena azygos; in serpents, of the right renal, and all the intercostal veins; in fish, of the renal veins, the tail, and genitals. They assert, that in pneumonia and phthisis more bile is secreted, and in the *blue disease*, and other affections of the heart, that the liver is enlarged. The constituents of the bile contain a large quantity of carbon, which is chiefly in union with hydrogen, and under the form of resin or fatty matter, and resin is most abundant in the bile of herbivorous animals, whose food contains a very large proportion of carbon and hydrogen. In the lungs the carbon may be said to be burnt, whence animal heat; in the abdomen it passes off still combustible.

SECT. XXVI.

OF THE FUNCTION OF THE SPLEEN.

388. The *Spleen*[a] lies to the left of the liver, with which it has considerable vascular communications; with its oblong figure,[b] it accommodates itself, as it were, to the contiguous viscera, but is liable to great varieties in point of form, number, &c.[c]

389. Its colour is livid, its texture peculiar, soft, easily lacerated, and therefore surrounded by two membranes, the interior of which is proper to the spleen, and the exterior derived from the omentum.

390. The situation and size of the spleen are no less various than its figure, and depend upon the degree of the stomach's repletion; for, when the stomach is empty and lax, the spleen is turgid; when the stomach is full, the spleen, being compressed, is emptied.

It undergoes a continual, but gentle and equable, motion, dependent upon respiration, under the chief instrument of which — the diaphragm, it is immediately situated.

[a] Ch. Drelincourt, the younger, has carefully collected and concisely related whatever was known up to his time, respecting the spleen; *De lienosis,* at the end of his father's Opuscula. Boerhaave's edition, p. 710. sq.

Consult, also, Chr. Lud. Roloff, *De fabrica et functione lienis.* Frf. ad Viadr. 1750. 4to.

But among more recent writers, see L. J. P. Assolant, *Recherches sur la Rate,* Par. 10. 8vo.

C. F. Heussinger, *über den Bau und die Verrichtung der Milz.* Isen. 1817. 8vo.

And Chr. Hellw. Schmidt, *Commentatio* (which gained the royal prize) *de pathologia lienis,* &c. Gott. 1816. 4to.

[b] Walter, tab. iii. G.

Mascagni, tab. xiv. P.

[c] See Sandifort, *Natuur en genees-kundige Bibl.* vol. ii. p. 345. sq.

391. Its texture was formerly supposed to be cellular, and compared to the corpora cavernosa of the penis. This opinion was proved to be erroneous by more careful examination of the human spleen,[d] which consists entirely of blood-vessels, of enormous size in comparison with the bulk of the organ. They are, in fact, proportionally more considerable than in any other part of the body.

392. The experiments of Wintringham demonstrate the great tenuity and strength of the coats of the splenic artery. It is divided into an infinite number of twigs, the terminations of which resemble pulpy penicilli and give rise to the splenic veins, which gradually unite into large, loose, and easily dilatable, trunks.

393. This immense congeries of blood-vessels is connected and supported by a sparing cellular parenchyma, from which the absorbents arise. The trunks of these run along the lower surface of the spleen between the two coats just described.[e]

394. This loose structure of the spleen, easily becoming distended with blood, admirably confirms what we formerly remarked respecting the turgor of this organ (390). The congestion and slow return of the splenic blood, if the nature of the neighbouring organs is also taken into consideration, illustrates its peculiar properties, which may throw some light upon the function of this enigmatical viscus — the source of so much controversy.

395. The splenic blood is very fluid, coagulates with great difficulty, separates the serum from the crassamentum imperfectly, and is of a livid dark colour, like the blood of the fœtus. These circumstances clearly demonstrate the abundance in it of carbonaceous matter; which is likewise proved indisputably by an easy experiment. Whenever I have ex-

[d] See Lobstein's Dissertation, *Nonnulla de Liene sistens.* Argent. 1773. 4to.

[e] The singular and rather paradoxical opinions of Hewson, without doubt, a very superior man, respecting the functions of the spleen, may be found in his posthumous work, entitled *Experimental Inquiries.* Part III. London. 1777. 8vo. C. ii. S. xlv. sq. xcv. sq.

posed sections of a recent spleen to oxygen gas, they have acquired a very bright red colour, while the air, losing its oxygen, has become impregnated with carbon.

396. But since the spleen is the only organ of that description quite destitute of an excretory duct excepting its veins which run ultimately to the liver, its function is probably subservient to that of the latter. This opinion has appeared strengthened by the observation, that in animals from which the spleen has been removed,—a remarkable experiment very frequently made from the most remote period,[f] the cystic bile is sometimes found pale and inert.

397. Besides at least twenty hypotheses respecting the use of the spleen, two of more weight have been lately advanced, both supposing a connection between the spleen and *stomach*, but the one[g] regarding the spleen as a diverticulum to the arterial blood destined to form the *gastric juice;* (A) the other,[h] supported by excellent arguments and experiments, making the spleen to receive a great portion of our *drink* from the *cardiac* extremity of the stomach, so that these may pass through a short cut, hitherto unknown, from the stomach to the spleen, and thus into the mass of blood. The latter hypothesis, especially if a few objections were removed,[i] is highly deserving of further examination. (B)

[f] J. H. Schulze, *De splene canibus exciso.* Hal. 1735. 4to.

[g] Vinc. Malacarne, *Memorie della Soc. Italiana,* t. viii. P. 1. p. 233.

A. Moreschi, *Del vero e primario uso della milza.* Milan, 1803. 8vo.

[h] Ever. Home, *Phil. Trans.* 1808. More lately, however, in the same Transactions, for 1811, this very acute author regards the spleen rather as a secreting organ, and its large and numerous lymphatic vessels, running to the thoracic duct, as supplying the place of an excretory canal.

[i] For instance, the size of the spleen in those warm-blooded animals which never drink; or in bisulcous animals, whose spleen adheres to the paunch, receiving the crude food only, but never the drink, which is prevented from entering it by the well-known mechanism of a semicanal running from the œsophagus to the omasum.

NOTES.

(A) This opinion was proposed a century ago, by Dr. Stukely.[k] Considering the spleen to consist entirely of complications and inosculations of arteries, veins and cells, nerves, and (as Malpighi asserted) "a muscular net-work of fibrillæ," he supposed that it contracted and propelled its blood through the splenic vessels into those of the stomach, when this organ required a larger supply during digestion. (p. 37.) He maintained, likewise, that it accelerated the motion of the blood in the mesenteric veins when the circulation in the vena portæ was sluggish, and that it answered various other purposes. The whole is an hypothesis now forgotten: the spleen has no muscularity.

Some have thought it a diverticulum for the blood whenever this fluid is obstructed in any part of the body, as in the cold stage of fever, great efforts, &c. To prevent too much being thrown upon organs that might be injured, the spleen, they contend, is formed to allow an accumulation in its substance. This is ingeniously defended by Dr. Rush.[l]

Dr. Haighton (Lectures at Guy's Hospital), and Mr. Saumarez (*New System of Physiology*), have explained its operations as a diverticulum in a very different manner. When the stomach is full, the compression experienced by the spleen impedes its circulation, and the blood makes its way the more copiously into the arteries of the stomach, liver, &c. But we have no proof that the repletion of the stomach compresses the spleen materially, and thus can impede its circulation: a fact, indeed, which will be mentioned presently, renders this improbable. Besides, in ruminating animals, as Blumenbach observes, it lies next the first stomach or paunch, and if compressed, must be so before digestion begins; and in proportion as the fourth stomach fills and digestion proceeds more actively, is the distension of the paunch diminished. It varies in situation in different animals, not being always attached to the stomach. The excitement, too, which the liver must experience

[k] *Of the Spleen, its description and history, uses and diseases, particularly the vapors, with their remedy. Being a lecture read at the Royal College of Physicians.* By Wm. Stukely, M.D. C.M.L. and S.R.S. London, 1722. folio.

[l] Cox's *Medical Museum*, Philad. 1807.

when chyme irritates the extremity of the ductus choledochus, and still more the provision of a gall-bladder, must render such aid from the spleen superfluous to the liver. The infinite blood-vessels and excerning orifices of the stomach cannot, likewise, but furnish sufficient gastric juice, from the mere excitement which they must experience whenever the stomach contains food. No other glands habitually excited to occasional great activity have such a diverticulum.

A third view of its influence as a diverticulum is, that it serves for receiving a great part of the venous blood of the intestines during chymification and especially during chylification. When this process is going on, there must be a great increase of blood flowing to the alimentary canal; the vena portæ, through which it all flows, can dilate to only a certain extent, and in order to prevent such a congestion in the mesenteric veins as would retard the circulation in the organs, the spleen allows an accumulation in itself. Leuret and Lassaigne found the spleen of a dog weigh a pound and a half in two hours after the application of a ligature to the vena portæ, while it ordinarily weighs but two ounces; and observe that it has a vermillion tint when an animal is fasting, but grows turgid and of a dark purple when the chyme has passed the pylorus.

If the opinion of Erasistratus that the spleen is useless, was a little atheistical, the notion of Paley was not much better, — that the viscera contained, and the abdomen containing, are so clumsily adapted to each other, that a pad is necessary to make them fit, just as hatters put stuffing under the leather of a hat which is made too big for the head, — "It is possible, in my opinion, that the spleen may be merely a stuffing, a soft cushion to fill up a vacuum or hollow, which, unless occupied, would leave the package loose and unsteady." [m] When I consider the stupendous power and design displayed throughout nature, I instantly revolt at such an explanation as Paley's, to say nothing of its anatomical absurdity.

(B) Sir Everard Home's friends having, among other experiments, passed a ligature around the pyloric extremity of the stomach of a dog, injected into this receptacle a solution of rhubarb; and, on killing the animal some few hours afterwards, none of the absorbents of the stomach were found distended, nor could any

[m] *Natural Theology*, c. xi.

trace of rhubarb be detected in the liver, but evident traces existed in the spleen and in the urine. When fluids had been drunk, the spleen was turgid and exhibited cells full of a colourless liquid that were at other times collapsed and almost imperceptible, — a circumstance rendering it unlikely that the spleen is diminished in bulk by the distention of the stomach; for, first, compression sufficient to prevent the artery from sending into it the usual quantity of blood, would prevent the entrance of fluids by any other vessels; and, secondly, we learn that the spleen is actually distended by the fluid portion of the contents of the stomach.

During the distention of the spleen, when the pylorus was not tied, the rhubarb appeared more strongly in the blood of the splenic than in that of other veins. If coloured solids without fluids were introduced into the stomach, the cells of the spleen were not distended, nor did this organ or its veins give more signs of the colouring matter than others.

From later experiments, published in 1811, the writer completely changes his opinion. It seems that traces of rhubarb were discoverable in the bile as well as in the spleen: and that it tinged the urine if the spleen had been removed before the experiment: so that he abandons what he had before advanced as a discovery.

SECT. XXVII.

OF THE FUNCTION OF THE OMENTUM.

398. THE omentum gastro-colicum or magnum [a] (to distinguish it from the parvum or hepato-gastricum), [b] is a peculiar process of peritonæum, arising immediately from the external coat of the stomach.

399. Although there are innumerable continuations of the peritonæum in the abdomen, [c] and every abdominal viscus is so covered by it that on opening the abdomen nothing is found destitute of that membrane, nevertheless, it is afforded in different ways, which may be reduced to classes.

Over some the peritonæum is merely extended as a smooth membrane, or it affords to them only a partial covering, as is the case with respect to the kidneys, rectum, urinary bladder, and, in some measure, with respect to the pancreas and gall-bladder.

To some which project into the cavity of the abdomen, although adhering to its parietes, it affords a covering for the greater part of their surface; *v. c.* to the liver, spleen, stomach, uterus, and the testes of the very young fœtus.

The intestinal tube, with the exception of the rectum, projects so much into the cavity of the abdomen, that it is, as it were, suspended in loose processes of the peritonæum, called

[a] Eustachius, tab. ix.

Haller, *Icones anat.* fasc. i. tab. iv. K. M., and the Appendix Colica, which he himself investigated at Göttingen in 1740. ib. R.

Rob. Steph. Henry, *Descript. omenti c. icone nova.* Hafn. 1748. 4to.

[b] Eustachius, tab. x. fig. 1. G.H.

Haller, l. c. Q.

[c] C. J. M. Langenbeck, *Commentarius de structura peritonæi,* &c. Gott. 1817. 4to. with copper-plates.

mesentery and mesocolon: the broad ligaments of the uterus are similar to these.

400. The longest and most remarkable process of peritonæum, is the *omentum* — a large, empty, delicate, sac, hanging from the large curvature of the stomach, extended over the greater part of the small intestines, applying itself closely to their convolutions, and, in some measure, insinuating itself into their interstices.

401. Besides the blood-vessels seen upon the omentum, it is marked by fatty striæ or bands, which are every where reticulated (whence the German name (Netzhaut) of this membrane), and in corpulent persons increase occasionally to a large and even dangerous size, and, by their means, the whole omentum is lubricated with a halitus, which one might almost call adipose.

402. On the latter circumstance depends the use commonly ascribed to the omentum, — of lubricating the intestines and assisting their continual movements: this also appears the use of those analogous small bursæ which are found [d] in such numbers about the rectum [e] and colon. [f]

The omentum also prevents the adhesion of the intestines to the peritonæum, and the consequent impediment to the functions of the primæ viæ.

403. There is another two-fold office attributed with great probability to the omentum, [g] *viz.* that of facilitating the dilation of the viscera to which it is contiguous, and of acting as a diverticulum to their blood during their state of vacuity.

404. If we reflect on the singular structure of the omentum parvum or hepato-gastricum especially, we may be inclined to believe that there is another, and, perhaps, principal office attached to it, unknown at present, and discoverable by comparative anatomy.

[d] I have lately seen similar appendices on the peritonæal covering of an uterus unimpregnated, but which had formerly been pregnant.

[e] Walter, tab. ii. *m. m. m.*

[f] Bidloo, *Anatomia hum. corporis,* tab. xxxix. fig. 6. C.C.C. D.D.D.

[g] v. Chaussier, *Mémoires de l'Acad. de Dijon.* 1784. Semestr. iii. p. 95.

SECT. XXVIII.

OF THE FUNCTION OF THE INTESTINES.

405. The intestinal tube, over which the omentum is extended, and which receives the chyme to elaborate it further (362, 363), and separate the chyle from the fæces, is divided into two principal portions — the small and large intestines, of whose functions we shall speak separately.

406. The small[a] intestines are again divided into three: the duodenum, jejunum, and ileum.

The first is named from its usual length.

The second from generally appearing collapsed and empty.

The third from its convolutions: it is the longest of the three, fuller, and, as it were, inflated, and sometimes resembling the large intestines by the appearance of bullæ.

407. The coats of the small intestines correspond with those of the stomach. (354)

The *external* is derived from the mesentery.

The *muscular* consists of two orders of fibres: the one longitudinal, interrupted, external, and found especially about the part opposite the mesentery; the other, annular and falciform, possessing the power of narrowing the canal, while the former shortens it. Upon both depends the very great and permanent irritability of the intestines, formerly mentioned. (300)

The *nervous* coat is condensed cellular membrane, easily reduced by handling, or more particularly by inflation, into a spumous tela;[b] in it the intestinal blood-vessels, which arise

[a] Chr. Bernh. Albinus, *Specimen anat. exhibens novam tenuium hominis intestinor. descriptionem.* LB. 1724. 8vo.

[b] B. S. Albinus, *Annotat. Academ.* L. ii. tab. iv. fig. 1, 2.

from the mesenteric,[c] are distributed in a beautifully arborescent form;[d] the intestines, no less than the stomach, are indebted to it for their tenacity and strength.

The interior, lined by its delicate epithelium, and deserving the name of *villous* in the small intestines more than in any other part of the canal, forms, in conjunction with the inner surface of the former coat, here and there, undulated ridges and rugous plicæ, which, in dried and inflated intestines, resemble the blade of a scythe, and are termed the valvulæ conniventes or Kerkringhianæ.[e]

408. The *villi*, which are innumerable[f] upon the inner surface of the intestines, and whose beautiful and minute vascular structure was first carefully investigated, though described with exaggeration, by Lieberkühn,[g] may be, perhaps, compared, while destitute of chyle, to little loose pendulous bags, internally soft and spungy; but, when distended with chyle, they have the appearance of a morel.

409. The base of these villi is surrounded by innumerable *glandular follicles*, adhering chiefly to the nervous coat, and opening into the intestinal canal by a very small orifice, through which they discharge the mucus that lines the whole tract of the intestines.

These are distinguished into three orders. The Brunnerian, largest, distinct, found in most abundance in that part of the duodenum which is contiguous to the pylorus.[h] The

[c] Eustachius, tab. xxvii. fig. 2. 4.

[d] B. S. Albinus, *Dissert. de arteriis et venis intestin. hominis,* with coloured plates. LB. 1736. 4to.

Also his *Annotat. Acad.* L. iii. tab. i, ii.

[e] Kerkring, *Spicilegium anatomicum,* tab. xiv. fig. 1, 2.

[f] He estimated their number, in the small intestines of an adult, to be about 500,000.

[g] *De fabrica et actione villorum intestinor. tenuium hominis.* LB. 1745. 4to.

J. Bleuland, *Descriptio vasculorum in intestinorum tenuium tunicis.* Ultraj. 1797. 4to.

R. A. Hedwig, *Disquisitio ampullarum* Lieburkühnii. Lips. 1797. 4to.

C. A. Rudolphi, *Anatomisch-physiologische Abhandlungen.* Berlin. 1802. 8vo. p. 39.

[h] J. Conr. a Brunn, *Glandulæ duodeni s. pancreas secundarium.* Francof. 1715. 4to. fig. 1.

Peyerian, smaller, aggregated, found chiefly at the termination of the small intestines, — about the valve of the colon.[i] Lastly, the Lieberkühnian, the smallest, said to be distributed in the proportion of about eight to each villus.[k] The two former orders are so inconstant, that I am inclined to consider the view given of them in the plates alluded to, as morbid;[l] for I have more than once been unable to discover the slightest trace of fungous papillæ with a single pore, in the small intestines of healthy adults; while, on the contrary, in *aphthous* subjects, I have found nearly the whole intestinal tube beset with them in infinite numbers, both solitary and aggregated.[m]

410. As the gastric juice is poured into the stomach, so an *enteric* or *intestinal fluid* is poured into the small intestines, demonstrated, among other ways, by the common experiment, first, we believe, instituted by Pechlin.[n] It is probably of a nature similar to that of the gastric liquor, but an accurate investigation of it is a physiological desideratum. We can say nothing respecting its quantity, but Haller's estimate, — eight pounds in the twenty-four hours, is certainly excessive. (A)

411. The intestines agree with the stomach in this particular, that they have a similar, and, indeed, a more unquestionable, or, at least, a more lively, *peristaltic action*,[o] which occurs principally when the chymous pulp enters them. This it agitates by an undulatory constriction of different parts of the canal, and propels from the duodenum towards the large intestines. Although the existence of an antiperistaltic motion, causing a retrograde course to their contents,

[i] J. Conr. Peyer, *De Glandulis intestinorum.* Scafhus. 1677. 8vo. especially fig. 3.

[k] Lieberkühn, l. c. p. 17. tab. iii.

[l] The eminent Rudolphi thinks differently, l. c. p. 212.

[m] These intestinal *aphthæ* exactly resemble those tubercles which Sheldon, in a work which we shall presently quote, exhibits (Tab. 1.) as small ampullæ full of chyle.

[n] *De purgantium medicamentor. facultat.* p. 509. — tab. iv.

[o] Benj. Schwartz, *De vomitu et motu intestinorum.* LB. 1745. 4to.
J. Foelix, *De motu peristaltico intestinorum.* Trevir. 1750. 4to.

cannot be disproved, it is in health much weaker, and less common and important, than the former.

412. By these moving powers and by these solvents which are afforded by means of secretion, the chyme undergoes remarkable changes.[p] In the jejunum it becomes a more liquid pulp, equally mixed, of a grey colour, and acidulous odour: in the ileum it begins to separate into two parts — into the fæces, of a pale, yellowish, brown colour,[q] and nauseous smell — and the genuine chyle, swimming upon the former, extracted from the chyme, separated by the bile from the fæces, and destined for absorption by the lacteal vessels, as we shall find in the next section. (B) At present, we shall enquire what course is taken by the fæces.

413. These, after becoming more and more inspissated in their long course through the ileum, have to overcome the valve of the colon and pass into the large intestines. To fa-

[p] Consult the excellent observations and experiments of A. E. Ferd. Emmert, *Archiv. für die Physiologie*, t. viii. p. 145.

[q] We formerly (387) remarked, that the bilious colour of the fæces arose from the excrementitious part of the bile. In the jejunum, the bile being undecomposed and mixed with the equable pulp of the intestines, and consequently diffused and diluted, cannot exhibit its true colour. But after its separation into two parts, the excrementitious portion, mixed with the precipitated fæces, and, as it were, again concentrated, now discovers its original colour, and imparts it to the fæces.

C. F. Wolff (*Act. Petropolit.* 1779. P. ii. p. 245.) entertains a different opinion in regard to the cause of the bilious colour of the fæces contained in the ileum. He conceives that an addition of bile occurs near the extremity of the jejunum, *by exhaling from the gall-bladder and penetrating this part of the intestine and its contents*, and that this bile differing, perhaps, in its nature, from the bile of the choledochus, and not being mixed with the fæces as the latter is with the chyme, retains its colour through all the remaining tract of the intestines, and continues pure bile.

But, besides our being able easily to explain why this colour is not observable before the decomposition of the chyme and bile, it is extremely doubtful whether, during life and health, any exhalation can occur from the gall-bladder and penetrate the intestine. For in subjects recent and scarcely cold, we have seen the intestines but slightly tinged with bile, although dyed with it very deeply and extensively after a lapse of some hours or days, *i. e.* after the coats of the gall-bladder had lost their tone and become incapable of preventing the transudation of their contents.

cilitate this, the extremity of the ileum is lubricated very abundantly by mucus.

414. The *valve of the colon*,[r] or, as it may deservedly be termed after its discoverer, the valve of Fallopius,[s] is a short process or continuation of the portion of the ileum that penetrates into and is surrounded by the cavity of the large intestine. Its external lips, while a neighbouring fold of the large intestine at the same time projects considerably, are composed,[t] not like other similar folds, merely of the interior and nervous coats, but of fibres from the muscular coat also. Hence it performs the double office of preventing the passage of too great a quantity of fæces into the large intestines, and regurgitation into the small.

415. The large intestines, divided like the small into three parts, commence by the *cæcum* (which has a *vermiform process* whose use in man is unknown),[u] and afford a very ample

[r] Haller, *De valvula coli*. Gotting. 1742. 4to., reprinted in his *Oper. minor.* t. i. p. 580. sq.

T. Mich. Röderer, *De valvula coli*. Argent. 1768. 4to.

[s] The various opinions respecting the discoverer of this remarkable valve are well known. Haller's *Elementa*, t. vii. P. 1. p. 142., may be consulted on this point.

In the mean time I am certain that, long before the period at which its discovery is in general dated, it was accurately known to that immortal anatomist Gabr. Fallopius. In the library of our university there is a manuscript of Fallopius, containing, among other things, his *anatomy of the monkey*, in which is an account of the structure and use of the valve of the colon, delivered in a public demonstration at Padua, Feb. 2. 1553, in the following words: "*The use of the cæcum in the monkey, is to prevent the regurgitation of the food during progression on all fours. This is proved by the circumstance of water or air, thrown into the rectum, reaching the cæcum, but not passing beyond the large intestines. But, if impelled from above, it passes into them. The reason is this, — at the insertion of the ileum are two folds, which are compressed by inflation and repletion, as occurs in the heart, and prevent retrogression; wherefore, in man, clysters cannot pass and be rejected through the mouth, unless in a weak and diseased state of the intestines.*"

[t] A view of a recent and entire valve is exhibited by B. S. Albinus in his *Annotat. Acad.* L. iii. tab. v. fig. 1.

And overcharged by inflation and drying, in Santorini's Posthumous Tables, xiv. fig. 1, 2.

[u] Lieberkühn, *De valvula coli et usu processus vermicularis*. LB. 1739. 4to.

Joach. Vosse, *De intestino cæco ejusque appendice vermiformi*. Gotting. 1749. 4to.

receptacle, in which the fæces may be collected and retained, till an opportunity for discharging them arrives.

416. They exceed the small intestines in thickness and strength, as well as in capacity. The muscular coat has this peculiarity — that its longitudinal fibres, excepting at the extremity of the rectum, are collected into three bands, called ligaments of the colon;[x] and the intestines themselves are divided into a kind of bulbous segments. The inner coat is not so beautifully flocculent as that of the small intestines, but more similar to that of the stomach.

417. Their peristaltic motion is much fainter than that of the small intestines. On the other hand, they experience to a greater degree the pressure of the abdominal parietes, to which the whole length of the *colon* is contiguous.

418. They gently propel the fæces into the *rectum*, which thus becomes internally stimulated to discharge its contents. The discharge is facilitated by the absence of transverse rugæ, and especially by the great quantity of mucus at the extremity of the bowels.

419. It is principally effected by the pressure of the abdomen downwards, overcoming the resistance of the os coccygis and of both sphincters, the inner of which is a remarkable bundle of circular fibres, the outer, a truly cutaneous muscle. After the excretion, the effort of the abdomen having ceased, the levator ani chiefly retracts the intestine, which is again closed by its sphincter.[y] (C)

NOTES.

(A) Pechlin's experiment was simply to include a portion of intestine between two ligatures, so that the fluid secreted into the canal might be collected.

[x] Eustachius, tab. x. fig. 2. 4, 5.

[y] All these parts may be seen as they exist in each sex, in Santorini's Posth. Tables, xvi, and xvii.

(B) A great part of the chyle is generally formed and absorbed before the digested mass reaches the ileum.[z] On arriving in the large intestines, the mass undergoes fresh changes, at present unexplained, and is converted into excrement.[a] Here it is that the true *succus entericus* must be poured forth, for the secretion into the small is probably nothing more than mucus and a simple watery fluid. Tiedemann and Gmelin support, in some measure, the old idea of the cæcum being a subsidiary stomach, from its contents being acid, although acidity had disappeared higher up in the canal, and more acid as the aliment is less digestible; and from albumen often reappearing suddenly in this part of the canal. Dr. Prout found the fluids of the large intestines coagulate lymph even as low as the rectum. The excrementitious mass, consisting of the indigestible part of the food, the resin, and colouring and fatty matter of the bile, with intestinal mucus, loses its fluids gradually as it descends, and in the rectum becomes particularly dry.

The gas of the stomach contains, besides azote and carbonic acid gas, oxygen, and very little hydrogen; while that of the small intestines contains, besides the two former gases, no oxygen, and abundance of hydrogen: that of the large intestines has less hydrogen and carbonic acid, and likewise no oxygen. Little or no gas is found in the stomach during chymification.

The following are the results of MM. Magendie's and Chevreuil's analysis of the gases of the alimentary canal:

In the stomach of a man just executed, —

Oxygen - - -	11,00
Carbonic acid - -	14,00
Pure hydrogen - -	3,55
Azote - - -	71,45
	100,00

In the small intestines of a subject, four-and-twenty years of age, who had eaten, two hours before execution, bread and Gruyère cheese, and drunk eau rougie, —

[z] Dr. Prout, Thomson's *Annals of Philosophy*. 1819.

[a] See Abernethy, *Surgical Observations*, Part II. p. 34.

Oxygen - - -	0,00
Carbonic acid - -	24,39
Pure hydrogen - -	55,53
Azote - - -	20,08
	100,00

——— twenty-three years of age, who had eaten the same food, and was executed with the former, —

Oxygen - - -	0,00
Carbonic acid - -	40,00
Pure hydrogen - -	51,15
Azote - - -	8,85
	100,00

——— twenty-eight years of age, who, four hours before execution, had eaten beef, bread, lentils, and drunk red wine, —

Oxygen - - -	0,00
Carbonic acid - -	25,00
Pure hydrogen - -	8,40
Azote - - -	66,60
	100,00

In the large intestines of these three criminals, were found, —

Oxygen - - -	0,00
Carbonic acid - -	43,50
Carburetted hydrogen and some traces of sulphuretted hydrogen	5,47
Azote - - -	51,03
	100,00

Oxygen - - -	0,00
Carbonic acid - -	70,00
Hydrogen and pure carburetted hydrogen - -	11,06
Azote - - -	18,04
	100,00

The gas of the cæcum and rectum of the third was examined separately.

Cæcum, —

Oxygen - - -	0,00
Carbonic acid - -	12,50
Pure hydrogen - -	7,50
Carburetted hydrogen -	12,50
Azote - - -	67,50
	100,00

Rectum, —

Oxygen - - -	0,00
Carbonic acid - -	42,86
Carburetted hydrogen -	11,18
Azote - - -	45,96
	100,00

Some traces of sulphuretted hydrogen appeared upon the mercury before the last analysis was commenced.

Berzelius finds human excrement to consist of

Water - - -	73,3
Remains of vegetable and animal matter - - -	7,0
Bile - - -	0,9
Albumen - -	0,9
Peculiar extractive matter -	2,7
Matter composed of altered bile, resin, animal matter, &c. -	14,0
Salts - - -	1,2
	100,0

The gases are probably disengaged from the contents of the canal; but I believe, with John Hunter,[b] that it often secretes gaseous fluids. For mental emotion will suddenly cause extreme discharges of air from the stomach, and the intestines to swell with wind. In many diseases the same will occur, although no fermentation or unusual change is discernible in the contents of the canal. Emphysema has occurred without any wound of the lungs; and air in the serous membranes, or in the cellular, is known to be absorbed.[c]

[b] *Observations on certain parts of the Animal Economy.*

[c] See Dr. Baillie in *Transact. of Society for Improvement of Med. and Surg. Knowledge*, vol. i.

The excrements of brutes have been analysed, but not to an extent capable of affording general views.

(C) Every one knows that the intestines are usually relieved once in twenty-four hours, but that some little variety occurs in this respect. In cases of extreme abstinence, they of course discharge their contents very rarely, as I mentioned formerly. Heberden, however, mentions a person who naturally had a motion once a month only, and another who had twelve motions every day during thirty years, and then seven every day for seven years, and rather grew fat than otherwise. [c]

Pouteau's young lady, mentioned at page 303, had no stool, he says, for upwards of eight years, although during the last year she ate abundantly of fruit, and drank coffee, milk, and tea, and broth with yolks of eggs: but she had copious greasy sweats.

[c] *Commentarii*, p. 14.

SECT. XXIX.

OF THE FUNCTION OF THE ABSORBENT VESSELS.[a]

420. The chyle, which we left in the ileum just separated from the fæces, must evidently be a mixture of different fluids. The proportion derived from the *secretions* — the saliva, the gastric, pancreatic, and enteric fluids, the bile, &c., surpasses, without the least doubt, that which is derived from the aliment, although this cannot be accurately ascertained. Hence must be derived the solution of the problem, — how ingesta of such various kinds can be converted into the chyle[b] — a fluid constantly of the same appearance, homogeneous, and of an animal nature.

421. The course of the chyle from the intestines to the blood, is through a part of the absorbent system, which we have hitherto only hinted at, but shall now speak of particularly. It is divided into four parts — lacteal and lymphatic vessels, conglobate glands, and the thoracic duct. Each of these will now fall under consideration.

422. It is certain that the lacteals originate among the villi of the internal coat of the intestines; but whether they are an immediate continuation of these villi, or merely connected with them by a cellular medium, admits a question. I myself have never been able to trace them so far as to discover their immediate connections with the villi, but they appear to arise here and there in the coats of the intestines, by a conspicuous

[a] A very copious list of writers upon the absorbents will be found in Sömmering's work, *De morbis vasorum absorbentium corporis humani.* Francof. 1795. 8vo.

[b] Ant. Müller, *Experimenta circa chylum.* Heidelb. 1819. 8vo.

trunk, and we may conjecture that they take up the chyle from the cellular structure into which it is first drawn by the villi. This I have in fact observed repeatedly in puppies, after making them swallow a solution of indigo, according to the celebrated experiment of Lister,[c] an hour or two before opening them alive.[d] (A)

423. The trunks just mentioned run some inches along the surface of the intestines, under the external coat, sometimes meandering in an angular course, before they reach the mesentery.

424. In their course through the mesentery they run into the mesenteric glands, of which there are two series. The one nearer the intestines, dispersed, small, and resembling beans in shape; the other, nearer the receptaculum chyli, large, and aggregated.

425. Both appear nothing more than closely-compacted collections of lacteals, interwoven with innumerable blood-vessels,[e] and retarding the course of the chyle; to the end, perhaps, that it may be more intimately and perfectly assimilated to an animal nature, previously to its entrance into the thoracic duct, and its mixture with the blood. (B)

426. It has been inquired whether lacteals exist also in the large intestines, and their existence has been advocated, from the effects of particular injections, nutrient, inebriating, &c., and also from the circumstance that the fæces, if retained for any length of time, become hard and dry. Although these arguments do not demonstrate the absorption of genuine chyle below the valve of Fallopius, nevertheless it is rendered probable by the visible existence of an abundance of lymphatics, in the large intestines,[f] having the same structure and

[c] *Phil. Trans.* No. 143., compared with No. 275.

[d] This experiment, which was repeated with the same result by Haller, Fœlix, J. Hunter, and others, has not succeeded in the hands of the distinguished Tiedemann and Gmelin, who have therefore expressed doubts respecting it in their excellent work, *über die Wege auf welchen Substanzen aus dem Magen und Darmkanal im Blut gelangen*, &c. Heidelb. 1821. 8vo. p. 61. sq.

[e] Boerhaave and Ruysch, *De fabrica glandularum opusculum*. LB. 1722. 4to. p. 81.

[f] Mascagni, tab. xvi.

function with the lacteals; for these absorb lymph from the intestines, [g] during the absence of chyle.

But the very different structure of the internal coat of the large intestines from that of the villous coat of the small, strongly argues that they are not naturally intended to absorb chyle.

427. There is another question more important and difficult of solution, — whether all the chyle absorbed from the small intestines passes through the thoracic duct, or whether some enters the blood by more secret passages. [h]

The latter opinion rests upon very unstable arguments. Thus the assertion of Ruysch, — that the mesenteric glands become, in advanced life, indurated and unfit for continuing their functions, was long since disproved: and affections of these glands, swellings, &c., are improperly called obstructions, [i] as the glands remain pervious, readily allowing a passage to quicksilver. The well-known phenomenon of tepid water, injected after death into the mesenteric veins, passing into the cavity of the intestines, has little weight with me in regard to a function which occurs during life; and much less weight can be allowed to the brass tube with two legs and two branches invented by Lieberkühn [k] to prove the existence of

[g] See Nuck, *De inventis novis ep. Anatomica,* p. 146. sq.

[h] T. Gothofr. Brendel, *De chyli ad sanguinem publico privatoque potissimum commeatu per venas mesaraicas non improbabili.* Gott. 1738. 4to.

[i] v. J. Rezia, *Specim. Observat. Anatomicar. et Pathologicar.* Ticini. 1784. 8vo. p. 18.

[k] The circumstance of life continuing, although in a weak state, for many months after the rupture of the thoracic duct (an instance of which is related by Lentin, *Beytr. zur ausüb. Arzneywissensch.* vol.i. p. 277. and 294.), would be a stronger argument, if extraordinary and unnatural phenomena of this kind could render the regular functions of the healthy human body doubtful, since, in explaining physiological phenomena, we look for natural, to use the words of Seneca, and not rare and fortuitous causes. Who, for example, would entertain a doubt of the functions of the uropoietic organs, because some poor creatures whose urethra was closed from a badly managed wound, have for many years discharged urine by vomiting nearly every day and in proper quantity. A remarkable case of this kind is carefully described by Zeviani, *Memorie di Matemat. e Fisica della Soc. Italiana,* t. vi. p. 93.

these passages. (C) The assertion — that chyle has been seen in the mesenteric veins,[l] requires farther investigation and proof; so that I cannot believe that they, at least after birth,[m] carry any thing more than blood, very carbonised and destined for the formation of bile.[n] (D)

428. The ultimate trunks of the lacteals, arising, like the lymphatics, from the combination of a great number of small twigs,[o] unite into the *receptaculum* or *cisterna chyli*, — the appellation by which the lower and larger part of the *thoracic* or PECQUETIAN *duct* is distinguished.

429. This duct is[p] a membranous canal, slender, strong, more or less tortuous, subject to great varieties in its course and division,[q] destitute of muscular fibre and nerves, and possessing here and there valves. At about the lowest cer-

[l] Werner and Feller, l. c. p. 12. sq.

[m] For that the passage of the yolk into the incubated chicken, takes place differently, at least as far as I can judge, I have mentioned in the *Handb. der vergleichend. Anat.* p.542. ed.2.

[n] There have been various disputes of late respecting the terminations of both lacteals and lymphatics (viz. whether they belong ultimately and solely to the principal trunks presently (437) to be mentioned, or whether they are in a great measure inserted at once into neighbouring veins), and against absorption being a function peculiar to them, it being ascribed not only to the mesenteric but to other veins by some of the latest physiologists; respecting the different opinions of whom consult, among others,

B. Nath. Gottl. Schreger, *Fragmenta anatomica et physiologica*. Fas. I. Lips. 1791. 4to. p.26.

Flor. Caldani, *Riflessioni sopra alcuni punti di un nuovo sistema de' vasi assorbenti*, &c. Padua, 1792. 8vo. p.58.

And his uncle Leop. M. A. Caldani's Commentary in the *Memorie lette nell' Accad. di Padova*. 1804. 4to.

Fr. L. Kreysig, *Handb. der pract. Krankheitslehre*, ii. Th.1. Abth. p.436.

F. Magendie, *Précis de Physiologie*, t.ii. p.222. of the German translation, by C. F. Heusinger.

Mayer and Ribes, in Meckel's Promptuarium of Physiology, vol.iii. and v.

Also C. W. L. Jaeckel, *de Absorptione venosa*. Berol. 1819. 8vo.

And Westrumb's Commentary, which is quoted below in Sect. XXXIV.

[o] Sheldon, l. c. tab. v.

[p] See Haller, *Observationes de ductu thoracico in theatro Gottingensi factæ*. Gotting. 1741. 4to.

B. S. Albinus, *Tabula vasis chyliferi*. LB. 1757. large folio.

Mascagni, tab. xix.

[q] See *v. c.* J. C. Bohl, *Viæ lacteæ. c. h. historia naturalis*. Regiom. 1741. 4to.
Sömmering, *Commentat. Soc. Scient. Gottingens.* t. xiii. p. 111.

vical vertebra, after passing the subclavian vein, it turns back again,[r] and is inserted into this, being furnished with a peculiar valve at the point of insertion.

430. The motion of the chyle throughout its course is to be ascribed to the contractility of its containing vessels, to their valves, and to the vis-a-tergo. (E)

431. The use of the valve placed at the opening of the thoracic duct, is probably not so much to prevent the influx of blood, as to modify the entrance of the chyle into the vein,—to cause it to enter by drops.

By this contrivance, fresh chyle is prevented from having access to the blood so rapidly as to stimulate the cavities of the heart too violently and be imperfectly and difficultly assimilated; for fresh chyle consists of very heterogeneous elements, brought not only from the primæ viæ by the lacteals, but from every part of the body by the lymphatics.

432. These *lymphatics*,[s] which constitute the third part of the absorbent system, and resemble the lacteals in their structure and function, are much more, and perhaps, indeed, universally, diffused.[t] They arise principally from the mucous web, which we therefore called the grand bond of connection between the sanguiferous and absorbing system; (27) but in great numbers likewise from the external common integuments,[u] from the fauces and œsophagus, (330) the pleura and peritonæum, and from the thoracic and abdominal viscera.[x]

433. Their origin is similar to that of the lacteals in the intestines, so that the radicle of each lymphatic absorbs the

[r] v. Haller, *Opera Minora*, vol. i. tab. xii.

[s] Consult, among others already and hereafter quoted, J. F. Meckel, *De vasis lymphaticis glandulisque conglobatis*. Berol. 1757. 4to.

And Al. Monro, filius, *De venis lymphaticis valvulosis*. ib. same year. 8vo.

[t] W. Hunter, *Medical Commentaries*, P. i. p. 5. sq.

[u] J. Elliotson has adduced new arguments showing that cutaneous absorption has been doubted of late without good reason, in his notes to the English translation of these *Institutions*, p. 129. 3d edit. 1820.

[x] Mascagni, tab. i, ii, iii.

T. Gottl. Haase, *De vasis cutis et intestinorum absorbentibus*, &c. Lips. 1786. fol. tab. i.

fluid from the neighbouring cellular membrane, as from its territory, and propels it onwards.

434. The lymphatics have double valves, set more or less thickly in different parts; they almost all enter conglobate glands; those which are contiguous to each other anastomose here and there; and those found on the surface of certain viscera, as the lungs, liver, &c. form a most beautiful network.

435. Besides other aids to their functions, evident from what has already been said, no inconsiderable assistance is derived from the combination of great strength with thinness in their coats, by which they are enabled to support a heavy column of quicksilver. In the limbs, especially, the motion of the muscles, pressing them on every side, is highly useful in increasing their power.

436. But their principal action, by which they take up fluids more or less rapidly, eagerly absorbing some and absolutely rejecting others,[y] depends upon the peculiar modification of their vitality, and is ascribed by the very acute Brugmans to a certain *vita propria*. (42)[z]

437. The far greater part of these lymphatics terminate in the thoracic duct; except, however, those of the right arm, the right side of the neck, the right lung, and the right portion of the diaphragm and liver, which terminate in the subclavian vein of the same side.

438. From the universal existence of the lymphatics, and especially from their great number on the surface capable of absorbing fluids from without, the heterogeneous nature of the lymph must be obvious; and this is further proved by

[y] On this remarkable difference consult T. Fr. Lucr. Albrecht, *Commentatio* (honoured with the Royal Prize) *in qua proponitur recensus eorum alimentor. et medicaminum, quibus, sive tubo alimentario sint ingesta, sive communibus corporis integumentis applicata, ingressus in systema vasor. sanguifer. aut concessus a natura, aut negatus sit.* Gotting. 1806. 4to.

[z] Conr. Jer. Ontyd (Præsidente Seb. Just. Brugmans), *De Causa absorptionis per vasa lymphatica.* Lugd. Bat. 1795. 8vo. p. 45.

v. Al. Van Hees, *De causa functionis absorbentis systematis lymphatici.* ib. 1817. 4to. p. 38.

accurately examining it in different parts of a subject; *v. c.* that contained in the hepatic or splenic lymphatics is perfectly different from that in the uterine.

439. We will enumerate the principal fluids which are continually absorbed during health, to say nothing of many different kinds of substances taken up during disease. There is, besides the chyle separated from the fæces in the small intestines, the halitus of the cavities, properly so called, especially that of the fauces and of all the mucous tela, the more watery part of those secreted fluids which are retained for some time in their ducts, *v. c.* in the breast, the vesiculæ seminales, the gall-bladder, &c. and not a small portion of the stillatitious fluids which are applied to the common integuments.[a]

440. The solids, after performing their purpose in the economy, insensibly melt away and are absorbed, as is proved by the absorption of the greater part of the thymus gland during infancy, of the roots of the first teeth, and of the alveoli after the second teeth have fallen out. The constant change of the whole osseous system, arising from the insensible renovation of the bony matter, of which we have treated elsewhere professedly,[b] may also be adduced.

441. It is therefore evident, since so great a variety of matter is absorbed, and at the same time nothing crude or improper allowed to enter the blood, that there is a necessity for some peculiar medium to previously subact and assimilate the various substances.

442. It appears to be the chief office of the *conglobate glands*, which constitute the last part of the absorbent system, to prevent the ill effects upon the heart of the improper admixture of crude fluid[c] with the blood, by assimilating the extremely

[a] Consult, among others, Valer. Lud. Brera, *Anatripsologia;* fourth edition. Pavia, 1799. 2 vols. 8vo.

A. J. Chrestien, *De la méthode iatroliptice.* Montpell. 1803. 8vo. In German, Gotting. 1813. 8vo.

[b] Decade 1. *Collection of the crania of different nations,* p. 27.

[c] If we consider the winding course which nature has provided for the purpose of changing and assimilating the absorbed fluids before their admixture with

various fluids more and more to an animal nature, by retarding their motion, and perhaps also by superadding to them some fresh secreted fluid. (F)

443. Those glands which are dispersed generally through the body, and aggregated here and there, as in the groin and axillæ, are perfectly similar to those found in the mesentery, consisting, like them, in a great measure, of convoluted absorbent vessels, supplied with an immense number of blood vessels, and liable to the same diseases.[d] (G)

NOTES.

(A) Dr. W. Hunter, Mr. Cruikshanks, and others, are said to have seen the *villi* of the intestines perfectly white in a person who had died soon after eating, and twenty or thirty orifices, in a single villus, forming tubes that ran to its base and united into one trunk.[e]

(B) If a gland is well injected, the numerous ramifications of the absorbents prevent cells from appearing, but if injected less minutely, cells are very evident, and distinct from the convolutions and ramifications of vessels. "If an absorbent gland of a horse is filled with quicksilver and dried, and then carefully slit open, the cells will be seen of a large size, and bristles may with ease be passed through the openings by which they communicate." It is imagined that the vasa inferentia pour their contents into these cells, and that the efferentia afterwards absorb it from them.

---

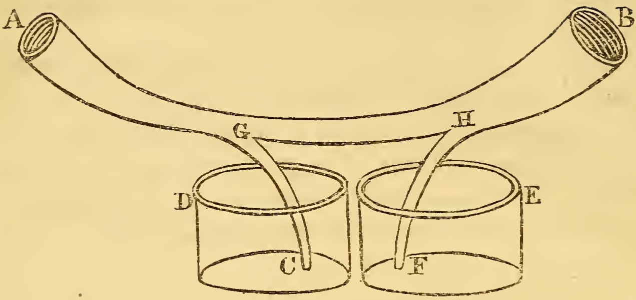
the blood; and, on the other hand, the dreadful symptoms, such as palpitation, convulsions, &c., which ensue upon the *artificial infusion* of a minute portion of any mild fluid into the blood, we shall be inclined to believe that those absorptions which Haller endeavours to prove are accomplished by the veins, do really take place by means of the lymphatic system. *De c. h. Funct.* vol. i. p. 281. sq.

[d] Nuck, *Adenographia Curiosa.* LB. 1696. 8vo.

[e] Wilson, *Lectures on the Blood*, &c. p. 198.

[f] Wilson, l. c. p. 203. Mr. Abernethy has described them in the whale as well as in the horse. *Phil. Trans.* 1796.

(C) Lieberkühn's tube was of this shape: —



Water propelled into A, passed out at B and C, but not at F. Even if F was immersed in a coloured fluid, this ascended to H, and passed out at B with the water.

A G may represent an artery, and G C a branch of it, opening into the cavity of the intestines; B H a vein, and H F one of its branches, doing the same.

(D) Dr. Magendie[g] contends that the lacteals absorb nothing but chyle, asserting that neither he nor Hallé have ever seen the chyle in these vessels tinged by coloured ingesta, and that neither he nor the veterinary surgeon Flandrin ever found any thing but chyle enter the lacteals. Lister's experiment has succeeded with Blumenbach, John Hunter, Fordyce,[h] and numerous others, and Hunter in the presence of several persons poured milk into the intestines of a dog, and they all observed it quickly to fill the lacteals. Among other insignificant objections, Dr. Magendie urges that Hunter should have first noticed whether the vessels contained chyle, whereas it is expressly mentioned that before the milk was poured into the intestine, the lacteals were seen distended by a nearly colourless and pellucid fluid.[i]

Tiedemann and Gmelin, however, have made an abundance of these experiments with the same result as Magendie, though in some few instances the substance introduced into the canal was discovered in the chyle.

He also revives the old opinion — that the lymphatics arise from arteries only, and are destined to convey lymph from them.[k]

[g] *Précis Elémentaire, &c.* t. ii. p. 178. sq.

[h] *On the Digestion of the Food,* p. 122.

[i] *Medical Commentaries.*

[k] l. c. p. 185. sq.

John Hunter, after pouring water coloured by indigo into the peritoneum of an animal, saw the lymphatics filled with a blue fluid. In the hands of MM. Magendie, Flandrin, and Dupuytren, this experiment likewise has failed. Magendie does, however, allow, that, in a woman who died with a collection of pus in the thigh, the surrounding lymphatics were distended with pus to the size of a crow's quill ; — a pretty decisive fact. The absorbents of fish have no valves except at their termination in the red veins, and may therefore be injected from the principal trunks : the injection passes out of the mouths of the absorbents in numerous streams, and especially on the back, if the skate is employed ; — another decisive fact. Peyer, Fallopius, and Kerkring saw bile in lymphatics about the liver. Down to Boerhaave and Haller the doctrine that the lymphatics absorb was maintained, and it was first seriously attacked by Dr. William Hunter. Dr. Munro soon afterwards did the same, and commenced a very acrimonious quarrel with Dr. William Hunter for the honour of priority of attack. Dr. Baillie expressly states, that Dr. Hunter had delivered such opinions six years before Dr. Munro professes to have made his discovery, and the world has generally given priority to Dr. Hunter. Dr. Munro had also an equally acrimonious dispute with Mr. Hewson for the honour of the discovery of the lymphatics in fish, but the Royal Society adjudged Hewson the Copley medal in 1769 for the discovery. It is amusing to reflect that the very doctrine, for the honour of having first attacked which so much violence was shown, is now again in high favour, and that Dr. Munro would be now lauded had he shown that Dr. Hunter only had attacked it.

The ancient doctrine of veins being organs of absorption forms a prominent feature in Dr. Magendie's physiology.[1] John Hunter deposited various fluids in the intestines, but, although he found manifest traces of them in the absorbents, he could discover none in the mesenteric veins. Dr. Magendie, however, relates two experiments in which a decoction of nux vomica, introduced into the alimentary canal, produced its usual effects, notwithstanding the thoracic duct was tied and ascertained to be single. In fact, Sir Everard Home, many years ago found substances to be taken into the circulation and into the urine from the stomach, though

[1] l. c. t. ii. p. 200. sqq. 257. sqq.

the thoracic duct was tied.[m] In a similar experiment, instead of the thoracic duct being tied, the portion of intestine containing the solution was totally separated from the body, except in one artery and one vein: but here it may be said, that the poison might be conveyed by absorbents in the coats of the vessels. Another experiment appears at first sight unobjectionable, because not only was every part of a limb separated from the body except the large artery and vein, but even these were cut asunder, quills having been previously introduced into them and fixed to carry on the circulation, and yet some upas plunged into the paw of the animal exerted its peculiar influence, which besides was suspended and permitted at pleasure by compressing or liberating the vein under the finger and thumb. But to all these experiments an objection presents itself: — 1. Many connections have been seen between absorbents and veins, *v.c.* Mr. Bracy Clarke discovered communications in the horse between the thoracic duct and lumbar veins,[n] and Mr. Abernethy traced lymphatic vessels to veins; Tiedemann and Gmelin, and many before them, propelled mercury into the vena portæ by absorbents; Mr. Cruikshanks long ago remarked, that in animals destroyed by violence the lymphatics about the spleen and in the cavity of the abdomen, in peritoneal inflammation sometimes the lacteals, and in peripneumony the lymphatics of the lungs, are tinged with blood, though no extravasation has occurred, and therefore he believed that lymphatics arise from the internal surface of arteries and veins;[o] the connection of the lymphatics with the veins, in the four classes of vertebrated animals has of late years been demonstrated by Lippi, Fohmann, and Louth, and in the Anatomical Museum of Heidelberg are numerous beautiful specimens, showing this fact:[p] and, 2. Dr. Magendie allows that the absorbents communicate with arteries, and may frequently be injected from them. Consequently, his poison might be imagined to be taken up by absorbents, carried into blood-vessels, and conveyed with the blood through the body. Indeed, when the poison was placed in a wound, it might contaminate the blood without being taken up by absorbing extremities of

[m] *Phil. Trans.* 1811.

[n] Rees's *Cyclopædia:* Anatomy, Veterinary.

[o] *On the Absorbents*, p. 50.

[p] Mr. Coulson's edition of Mr. Lawrence's translation of Blumenbach's *Manual of Comparative Anatomy*, p. 172.

vessels, and if Magendie is right in believing that fluids soak through even living solids, another objection is thus afforded. It is universally known, that, after death, fluids penetrate through the various textures of the body;— the aqueous humour diminishes in the eye, which consequently becomes flat, the intestines near the gall-bladder become yellow,[q] and water poured into the stomach or intestines exudes.[r] Dr. W. Hunter contended that this imbibition occurs also during life, although not in the case of blood-vessels, and others admitted it.[s] Dr. Magendie supports the same opinion. After separating a blood-vessel from the surrounding cellular membrane, and laying tincture of nux vomica upon it, the animal was poisoned, and the blood within tasted bitter; ink placed in the pleura of a young dog, dyed, in less than an hour, the pericardium, heart, and intercostal muscles. Dr. Fodera introduced a solution of prussiate of potass into the pleura, and of sulphate of iron into the abdomen of a living animal, when the two fluids became blue by union at the diaphragm, in five or six minutes, and instantaneously if a galvanic current was established.[t] Still there is not the slightest reason to imagine that the natural fluids of parts penetrate their substance during life and in a sound condition.[u] Dr. Magendie found absorption (of poisonous matters, for example, applied to surfaces) greatly impeded on rendering the vascular system turgid by injecting water into the veins, and equally accelerated on lessening the repletion by blood-letting. We should expect that the greater the repletion of the sanguineous system, the more difficulty must the contents of the absorbents have to advance, and *v. v.*; and from the wise arrangements observed in every function, we should conceive, that supposing absorption a vital action (as I cannot but believe it to be, as soon as a substance has fairly entered the vessel perhaps by mere physical attraction), the vessels would be less disposed to propel their contents in proportion as repletion existed. How it favours the idea of absorption being a mere imbibition through the coats of

[q] Hence, especially in a hot atmosphere, if the examination of a dead subject is long delayed, parts may become so dyed with imbibed blood, that their redness may be, and often is, mistaken for inflammation. See an important paper by Dr. John Davy, *Med. Chir. Trans.* vol. x.

[r] A. Kaau, *Perspiratio dicta Hippocrati.* 563.

[s] *Med. Commentaries.*

[t] *Journal de Physiologie,* t. iii.

[u] See Hewson's arguments against transudation, *Experimental Inquiry,* P. ii.

the absorbents, — a notion unsupported and contradictory to established facts, I cannot see.[x]

Against the result of an experiment in which, after a solution of prussiate of potass was swallowed, the salt was discoverable in the urine and not in the lymph, Dr. Magendie himself supplies an objection when treating of the urine. For he states, that a minute portion of this substance may be readily detected in the urine, while the quantity in the blood must be large to be discoverable. As the contents of the thoracic duct so nearly resemble blood, he should have ascertained whether it is not difficult to detect in them also a portion of the prussiate which would be easily manifest in the urine. A similar experiment with a decoction of rhubarb, lies under the same difficulty.

In starting all these doubts, I am only desirous of showing that Dr. Magendie's experiments are not so unobjectionable as he believes, and readily grant that John Hunter's experiments deserve repetition, and the whole subject farther investigation. I am not prepared to deny that veins absorb, or, what comes to nearly the same thing, that there are lymphatics which do not form trunks, but convey their contents to small blood-vessels; and I have nothing to suggest against the following facts.

"Three ounces of diluted alcohol were given to a dog; in a quarter of an hour the blood of the animal had a decided smell of alcohol; the lymph (of the thoracic duct) had none."[y]

"In the horse, the usual contents of both the large and small intestines are mixed with a large quantity of fluid that gradually decreases towards the rectum, and is therefore absorbed as it passes along the canal. Now, Flandrin, having collected the contents of the lacteals, did not find them smell like this intestinal fluid, whereas the venous blood of the small intestines had a taste distinctly herbaceous; that of the cæcum a sharp taste and a slightly urinous smell; and that of the colon the same qualities in a more marked degree. The blood of other parts presented nothing analogous.

"Half a pound of assafœtida dissolved in the same quantity of honey was given to a horse, which was afterwards fed as usual and killed in sixteen hours. The smell of assafœtida was perceptible in the veins of the stomach, small intestines, and cæcum; but not in the arterial blood, nor in the lymph."[z]

[x] In this I fully agree with Dr. Bostock, l. c. vol. ii. p. 587. sqq.

[y] *Précis de Physiol.* t. ii. p. 202. sq.

[z] l. c. t. ii. p. 267.

Dr. Segalas cut a portion of living intestine from the rest of the canal, and passed a ligature around its blood-vessels, leaving the absorbents free, and introduced a solution of nux vomica for an hour without ill effect: he then liberated the vein, and the animal was poisoned in six minutes.

In Tiedemann and Gmelin's experiments, among a variety of substances taken, coloured, odorous, or saline, very few could be detected in the chyle, but many were found in the blood.

(E) The force of their contraction is shown by the rupture of the thoracic duct from over-distention when a ligature is passed around it.[a] Tiedemann and Gmelin saw the thoracic duct contract from exposure to air.

(F) Although some albumen is discovered actually in the duodenum, and, as Dr. Prout allows, even in the stomach if animal food has been taken, and some fibrin in the first lacteals, the contents of the absorbents are found to possess more and more of these substances in proportion to their progress towards the left subclavian vein. The chyle contains a certain fatty matter, which is considered as *incipient albumen*, and, in proportion as this decreases, does the quantity of fibrin and albumen increase.[b]

The use of the conglobate glands is elucidated by the observations of Tiedemann and Gmelin, mentioned, p. 381. Amphibia and fish are said to have no lymphatic glands.[c] Dr. Magendie denied the existence of lymphatics in nearly all birds, but has been amply refuted by Dr. Louth and many others.

Dr. Carson argued that the thoracic vacuum would not only draw the blood along the veins, but draw it into their open mouths, thus being an agent of absorption. He concluded that the blood of the corpora cavernosa penis entered the veins in this way, but, as the lymphatics only were believed the organs of absorption, properly so called, when he wrote, he had not a more extended idea

[a] Sir Astley Cooper, *Med. Records and Researches*. A ligature of the thoracic duct does not necessarily deprive the body of nourishment, because there are sometimes two ducts, and sometimes one or more small trunks, which unite with it, or have a different termination in the venous system.

Dr. Magendie observed in the dog, that the contents of the thoracic duct flow but slowly, though more quickly during compression of the abdominal viscera.

On wounding it after a meal, he obtained half an ounce in five minutes, and they flowed for some time.

[b] Dr. Prout, in Thomson's *Annals of Philosophy*. 1819. p. 274.

[c] Blumenbach, l. c. p. 174.

of the co-operation of the vacuum in producing venous absorption. It must, however, evidently extend to every absorbing vein, and if the veins absorb generally, as is now believed, it must be general. As the great trunk of the absorbents terminates in a vein, they must be circumstanced in this respect exactly like veins, and equally subject to the influence of the thoracic vacuum. Indeed, Dr. Barry found that while a cupping-glass was applied over a wound to which poison was applied, no absorption occurred, no poisonous effects ensued: nor did they, even for some time afterwards; and when they became apparent, they instantly subsided on the re-application of the glasses. The pressure of the rim of the glass was not the cause of the non-appearance of poisoning, because if the deleterious substance was passed under the skin beyond the boundary of the glass, no ill effect occurred as long as the glass remained over the wound: an incision between the site of the poison and the rim, destroyed the efficacy of the glass.[d]

These experiments, however, do not prove that atmospheric pressure is the cause of absorption: they merely show its co-operation, and that the propulsive powers of the absorbents are insufficient when opposed by the removal of it. Pecquet, nearly two centuries ago, considered whether the chyle was absorbed by suction, and concluded against the opinion, by observing, that, if a ligature was placed upon the thoracic duct, or the lacteals of the mesentery, and all effect of vacuum thus prevented, the lacteals swelled on the intestinal side; therefore, said he, "non trahitur chylus sugiturve."[e] The pressure of ordinary respiration and of muscular efforts is also seen to drive the chyle forwards in the lacteals.

(G) A short account of the first discovery of the absorbent system may be acceptable at the close of this section.

Hippocrates knew that the nutritive portion of the contents of the alimentary canal was conveyed by certain vessels to the system. Erasistratus actually saw the lacteals containing chyle—

[d] *Experimental Researches*, p. 102. The application of a vacuum in poisonous wounds has been recommended from the days of Hippocrates to those of Dr. Parry (*Cases of Tetanus and Canine Hydrophobia*), but its effects never shown so beautifully as by Dr. Barry. He recommends that the cupping-glasses should be first applied for an hour; that the suppression of absorption for some hours being thus insured, the part should be excised, and then the glasses re-applied to remove any portion of the poison that may remain, for the vacuum was found to extract some of the poison.

[e] *Dissertatio Anatomica de circulatione sanguinis et chyli motu*, p. 76. Paris, 1651.

ἀρτηριας, γαλακτος πλήρεις. From Galen we learn that they were known also to Herophilus. From the year 150 to 1622 no advance was made, except that in 1563 Eustachius discovered the thoracic duct, but he remained ignorant of its use. In 1622 Aselli in Italy saw the lacteals by chance when demonstrating the recurrent nerves to some friends. Thinking they were nerves, he at first paid no attention to them; but soon observing that they did not pursue the same course as the nerves, and "astonished at the novelty of the thing, he hesitated for some time in silence," while all the circumstances of the controversy and quarrels of anatomists passed before his view. He had by chance been reading Costæus on this subject the day before, and, in order to examine the matter further, he "took a sharp scalpel to cut one of those chords, but had scarcely struck it when," he continues, "I perceived a liquor white as milk, or rather like cream, to leap out. At this sight, I could not contain myself for joy, but, turning to the bystanders, Alexander Tadinus and the senator Septalius, I cried out εὕρηκα! with Archimedes, and at the same time invited them to look at so rare and pleasing a spectacle, with the novelty of which they were much moved. But I was not long permitted to enjoy it, for the dog now expired, and, wonderful to tell, at the same instant the whole of that wonderful series and congeries of vessels, losing its brilliant whiteness, that fluid being gone, in our very hands and almost before our eyes, so evanished and disappeared, that hardly a vestige was left to my most diligent search." The next day he procured another dog, but could not discover the smallest white vessel. "I now," he says, with the same admirable *naïveté*, "began to be downcast in my mind, thinking to myself that what had been observed in the first dog, must be ranked among those rare things which according to Galen are sometimes seen in anatomy." At length he recollected that the dog had been opened "athirst and unfed," and therefore opened a third, after feeding him "to satiety." "Every thing was now more manifest and brilliant than in the first case." He gave his whole attention to the subject, and was so diligent that not a week, or certainly not a month, passed without a living dissection of dogs, cats, lambs, hogs, and cows, and he even bought a horse and opened it alive. "A living man, which Erasistratus and Herophilus of old did not fear to anatomise, I *confess* I did not open."

Notwithstanding this discovery of distinct chylous vessels, a large number of high authorities adhered firmly to the old opinion of Galen, that they were only mesenteric vessels. "There is not one among the doctors," we read in a letter of Thomas Bartholin written at Montpellier, during his journey to Italy, "who acknowledges the lacteal veins, so wedded are they to the authority of Galen, for which they contend as *pro aris et focis*, and disregard the experiments of the moderns." Unluckily, he did not trace the lacteals to the left subclavian vein, but fancied they went to the liver, distributing the chyle through it for sanguification; this organ, according to the established doctrine, receiving the chyle from the mesenteric arteries and veins to convert it into blood.

In 1649, Pecquet, a physician at Dieppe, was removing the heart of a dog, when he noticed a quantity of white fluid pouring from the upper cava mixed with blood. He at first thought he had opened some strange abscess, and, after pressing first upon one part and then upon another, he compressed the mesentery, whose lacteals were full of chyle, when instantly a large quantity of this poured from the superior cava. He traced the lacteals to the thoracic duct, and thus overthrew the doctrine of the liver being the great seat of hæmatosis.

Of course, there was as great an outcry against this innovation in doctrine, as there had been against the existence of lacteals, and even Harvey, who was now nearly eighty years of age, could not at once loosen himself from the bonds of early prejudice, and Thomas Bartholin, whose eyes had always been open to improvement in medicine, still thought that perhaps the finer parts of the chyle went by the new ducts to the chest, "while the grosser, needing a larger concoction, enter the liver."

About eighty years after the discovery of Asellius, Rudbeck, professor at Upsal, or Thomas Bartholin who was professor at Copenhagen and son of Caspar Bartholin, or Joliff, an English student, discovered the lymphatics.[f]

[f] See an interesting history of these discoveries, by Dr. Meigs, *Philadelphia Journal*, 1825. No. 2. New series. Haller gives the discovery to Rudbeck. Rudbeck says he first happened to see them while examining the hemorrhoidal vessels of a dog, Jan. 27. 1651. He published in 1653. Bartholin, that he first chanced to see them while dissecting a dog, Dec. 15. 1651., but did not notice them particularly till Feb. 28. 1652. He published in 1653. As to Joliff, we only read in Glisson, that, at the beginning of June 1652, going to Cambridge for his doctor's degree, he showed them to Glisson, who was then professor of medicine. Glisson published in 1654; Joliff never published, and probably had learnt the continental discovery while travelling. Bartholin is thought to have received a hint of Rudbeck's discovery.

SECT. XXX.

OF SANGUIFICATION.

444. There is scarcely occasion to remark that we employ the term sanguification to denote the assimilation of the chyle to the blood, and the constant reparation, by means of the *former*, of the constant loss sustained by the *latter*.

445. The division of all our fluids into three classes (45) — *crude*, *sanguineous*, and *secreted*, turns upon this; — that the middle class contains the stream of the vital fluid itself, from which the numerous secreted fluids are perpetually withdrawn, and to which, on the other hand, there is a constant afflux of chyle and lymph from the absorbent system.

446. But since the blood is a peculiar fluid, *sui generis*, without its fellow in nature, various assistances and media are evidently requisite to subact and assimilate the heterogeneous and foreign fluids which pass to it from the thoracic duct.

447. This is, in the first place, especially in the mesenteric and other conglobate glands, favoured by those windings, mentioned formerly, of the lacteals and lymphatics, which are, at the same time, gradually more impregnated, as it were, with an animal nature.

448. We must also take into consideration, that a great part of the lymph which enters the left subclavian after its admixture with the intestinal chyle in the thoracic duct, has been derived from the substance of the viscera and other soft parts, formerly secreted from the blood, and, therefore, already imbued with an animal nature, and easily, without doubt, again miscible with the mass of blood, to which it does but return.

449. Something is contributed by the slow and almost stillatitious manner in which the chyle joins the blood through

the last valve of the thoracic duct, these very minute portions becoming thus the more intimately combined with the blood.

450. The heart, too, by means of the remarkable papillary muscles of the ventricles, agitates and mingles the blood just impregnated with fresh chyle.

451. The great importance of the lungs which receive the blood immediately after its addition of fresh chyle, and also of respiration, in the business of assimilation,[a] will be evident on considering the extraordinary vascularity of those organs, (140) and their constant and regular alternate motion.

452. The remaining part of sanguification is accomplished by the general circulation and the powers which aid it, particularly by muscular motion, &c.

453. Although so many means are provided for the combination of the chyle with the blood, and although the constituents of the chyle somewhat resemble those of this fluid; nevertheless, it is commonly asserted that many hours are required for the complete change of the colour of the chyle and for its assimilation. Besides other arguments in favour of this assertion, the pathological fact is urged, that chyle is frequently seen in blood drawn many hours after digestion. I myself have witnessed this appearance in cases where the blood too evidently bore an inflammatory disposition, to use a common phrase; but I am persuaded that no inference can be hence deduced in regard to the healthy state, which alone is the object of physiology.

NOTE.

The fluid collected from the thoracic duct is opake and white; without smell; sweetish, and slightly acid to the taste; and re-

[a] Especially, according to the opinion of Cuvier, in the conversion of the chyle into the lymphatic or fibrous part of the blood. *Leçons d'Anatomie Comparée*, t. i. p. 91. t. iv. p. 304.

Consult Thomson, *System of Chemistry*, vol. iv. p. 497.

Also Bostock's work, recommended above in the chapter *On Respiration*.

stores the blue colour of litmus paper reddened by acetic acid, proving the presence of an alkali. It separates, like the blood, into a solid and a serous portion. If formed from vegetable food only, it is nearly transparent, may be kept weeks or even months without putrefying, and affords a faintly pink coagulum. If from animal food, it is white and opake, begins to putrefy in a few days, affords an opake coagulum which acquires a more marked pink hue by the influence of the atmosphere, and throws upon its surface a white creamy substance. The former gives three times as much carbon as the latter; but the latter being so much richer gives much more carbonate of ammonia and heavy fixed oil, when subjected to the destructive distillation.[b]

Chyle collected from lacteals is whiter, coagulates less perfectly, or not at all, and does not acquire a red colour by exposure to the air,[c] so that sanguification proceeds gradually, as the chyle passes towards the left subclavian vein, — a circumstance already stated in the last section, Note (F). The pink colour, acquired by the coagulum of chyle when exposed to the atmosphere, shows the use of the lungs in sanguification.

White globules exist in the chyle even at a very early period of its formation, and these most probably it is that become coloured when the chyle grows pink by the action of the air. There are also much larger white particles in the chyle, appearing to be formed of the caseous-like and oily principles, and, being insoluble in the serum, naturally assume the globular form.[d]

Dr. Marcet had reason to believe that the appearance of creamy matter floating in the serum of blood occurs most frequently when the food is chiefly animal, and when therefore rich chyle is poured into the blood faster than it can be assimilated. The serum at first appears milky; but it gradually becomes clear, from the creamy matter separating and rising to the surface.

The coagulum of the fluid of the thoracic duct is much less firm than that of blood, and after a few days, if allowed to remain in a separate vessel, it passes almost entirely to the fluid state. Vauquelin regards it as unfinished fibrin, something between albumen and fibrin.

[b] Dr. Marcet, *Med. Chir. Trans.* vol. vi. His observations were of course made upon the fluid obtained from brutes.

[c] Emmert, *Annales de Chimie,* t. lxxx.

[d] Dr. Prout, in Thomson's *Annals.* 1819. p. 275.

I once saw a young married woman whose urine contained very large coagula of chyle. She always dined at noon. In the evening the coagula were white; in the morning pale with pink streaks. After fasting twenty-four hours at my request, the coagula still appeared in the urine, extremely pale, and showing more pink streaks. She had been some months in this way, was in very fair health, and had a great appetite, and perhaps some other general symptoms of diabetes; but there was no sugar in the urine. Notwithstanding the fluid discharged seemed to present as much coagulum as urine, the quantity of chyle proved on drying to be very minute, and from its looseness to have been extremely distended by the urine. As this was a state of disease, I draw no inference from the case respecting the time necessary for the change of chyle to blood. She would not allow me to take any blood from the arm for observation.

I know that similar cases have been seen by Dr. Prout and other gentlemen now practising in London, and there may be several on record, but the only one of which I have read is quoted in Shenkius. "I saw," says the author whom he quotes (in Castro Itri, Comitatus Sundorum), "a young man, thirty years of age, who daily made a considerable quantity of urine, depositing a white substance like the curd of milk, sufficient to fill a common *pot de chambre*, besides the urine which was above it. He was in perfect health, not experiencing the slightest ill effect."[e]

Shenkius is generally thought a credulous collector of incredible cases, and no doubt some of his histories as well as of his opinions are ridiculous. But careful modern observation discovers facts precisely similar to the greater number that he has collected. I should have doubted the history just related, more especially the good health of the patient, had not the case of the woman occurred to me. He gives some instances of black urine made by persons in perfect health, and Dr. Marcet has published two such in the *Transactions of the Medical and Chirurgical Society*.[f] Dr. Prout showed me a specimen of urine from one of these.

[e] *Observat. Med. rariores*, lib. iii. Obs. 27. Dr. Charles Smith, of New Jersey, relates an example of ascites in a boy twelve years of age, where the fluid accumulated was of a chalky white colour, had pretty nearly the smell, taste, and appearance of milk, and threw up good cream after standing a night. Between seven and eight quarts of this were twice removed by tapping. *Philos. Mag.* vol. ix. p. 168.

[f] Vol. xii.

Lymph from the hind extremities of a horse was found by Emmert to be white, with straw-coloured globules, to contain rather less albumen, to coagulate more imperfectly, and become less easily red on exposure to air, than the contents of the thoracic duct.[g]

According to the recent observations of Tiedemann and Gmelin, the chyle has no fibrin, so as scarcely to coagulate, nor any red particles, before it passes through the mesenteric glands; but immediately afterwards, and especially after it is mixed with the lymph of the spleen, — a fluid abounding both with them and fibrin, — presents both, still more copiously than the lymph of the extremities.

No fatty matter is discoverable in the lymph, nor indeed in the chyle if the animal fasts or takes food destitute of fat. The fatty matter is merely diffused through the chyle, and found even in the blood after butter has been eaten.

The serum of the chyle they observed to be nearly always alkaline.

Ligature of the choledochus they found to augment the quantity of fibrin and red particles, and to diminish that of fatty matter, in the chyle.

[g] See also Vauquelin, *Annales de Chimie*, t. lxxxi. 181.

SECT. XXXI.

OF NUTRITION.

454. Besides the function of the blood formerly investigated, — of distributing oxygen (as is probable) through the system and removing carbon, its principal use is to afford nourishment to the body in general, and to the secreting organs the peculiar fluids which they possess the power of deriving from it. Nutrition shall be first examined.

455. *Nutrition* is the grandest gift of nature, and the common and highest prerogative of the animal and vegetable kingdoms, by which they, beyond measure, surpass, even at first sight, all human machines and automatons. Upon these no artist can bestow the faculty, not to say of increasing and of coming to perfection, but even of existing independently and repairing the incessant losses incurred from friction.[a]

456. By the nutritive faculty of the body, its greatest and most admirable functions are performed; by it we grow from our first formation and arrive at manhood; and by it are remedied the destruction and consumption which incessantly occur in our system during life.[b]

457. Respecting the nature of this consumption, there has been much dispute whether it affects the solids, [c] or, whether,

[a] "Nutrition, in fact, appears to be a continued generation," according to the old observation of the very ingenious Ent. See his work, already (290 g.) recommended.

[b] Th. Young, *De corporis humani viribus conservatricibus*. Gotting. 1796. 8vo. Fl. J. Van Maanen, *De natura humana sui ipsius conservatrice ac medicatrice*. Harderv. 1801. 8vo.

[c] See the great J. Bernouilli's Diss. *de nutrit.* Groning. 1669. 4to. He estimates the continual, though insensible, loss and reparation of the solids so high, that the whole body may be said to be destroyed and renewed every three years.

according to some very acute writers,[d] these, when once formed and perfected, remain invariably entire.

458. There can be no doubt that some of the similar solids, *v. c.* the epidermis and nails, are gradually destroyed and renewed; and the same is proved respecting even the bones, by the well-known experiment of dyeing them, in warm-blooded animals, with madder root, (A) and by the frequently surprising attenuation of the flat bones, especially of the skull, from defective nutrition, in old age.[e]

459. If I am not mistaken, those solid parts undergo this successive change, which possess the *reproductive power* — an extraordinary faculty, by which not only the natural loss of particles, but even the accidental removal of considerable parts through external injuries, is repaired and perfectly supplied, as the bones[f] and a few other parts sufficiently demonstrate.

460. On the other hand, I have been led by many experiments, upon man and other warm-blooded animals, to the conclusion — that this genuine *reproductive power* appears completely bestowed upon scarcely any similar solid part *which possesses any other vital power* BESIDES CONTRACTILITY, i. e. *irritability*, *sensibility*, or a *vita propria.*[g] (B)

[d] See J. Chr. Kemme, *Beurtheilung eines Beweises vor die Immaterialität der Seele aus der Medecin.* Halle. 1776. 8vo.

And his, *Zweifel und Erinnerungen wider die Lehre der Aerzte von der Ernährung der festen Theile.* Ibid. 1778. 8vo.

[e] Respecting this mutability of the bones, I have spoken at some length in my osteological work, ed. 2. p. 26. and elsewhere.

[f] Consult among others G. L. Koeler, *Experimenta circa regenerationem ossium.* Gotting. 1786. 8vo.

Alex. Herm. Macdonald, *De necrosi ac callo.* Edinb. 1799. 8vo.

[g] That the corium is not really reproduced, is probable, not only from its perpetual *cicatrices* (for some contend that the *matter* of these does not continue, but their *form* only, which is preserved by a perpetual apposition of fresh particles in the room of the decayed and absorbed), but much more by the lines and figures which are made upon the skin by the singular art of pricking it with a needle (a process denominated in the barbarous language of the Otaheiteans *tatooing*), and imparting to the corium a blue or red colour, as permanent as the cicatriculæ, by means of charcoal powder, ashes, soot, the juices of plants, or ox-gall; while on the other hand, the red hue imparted to the bones, by means of madder, quickly disappears, as these parts undergo a continual renovation.

461. In those parts, therefore, whose vital powers are, as it were, of a higher order, the parenchyma, constituting their base, appears permanent, and is liable to this change only, — that the interstices of the fibres and parenchyma, while nutrition is vigorous, are constantly full of nutrient animal gelatine; but, when nutrition languishes, are deprived of the gelatine, collapse, and consequently become thin.

462. For as the plastic lymph, the importance of which has been frequently mentioned, is readily converted into cellular membrane, so it appears to constitute the principal material of the body, and, as it were, the animal gluten, which is nourished by its means.

463. During the growth of the body, peculiar powers are exerted, by which the lymph deposited in the cellular membrane from the blood-vessels is properly distributed and intimately assimilated to the substance of each organ, &c.

This is referable both to the laws of affinity, by which we imagine particles attract, and, as it were, appropriate others which are similar and related to themselves; and to the nisus formativus, which we shall enlarge upon hereafter, and to which the proper application of shapeless elementary matter and its modification to particular forms must be ascribed.

464. The union of both these powers, we conceive, must be the source of the nutrition of such similar parts as are not supplied with blood itself, but are, nevertheless, at first generated by a most powerful and infallible nisus, grow, are nourished throughout life, and, if destroyed by accident, are very easily reproduced;[h] such are the nails, hairs, &c.

465. As this appears to be the true account of nutrition in general, so, on the other hand, this function evidently has great varieties of degree and kind, especially where, from the more

[h] *Zwo Abhandlungen über die Nutritionskraft welche von der Acad. der Wiss. in St. Petersburg den Preiss getheilt erhalten haben.* Petersberg. 1789. 4to.

De Grimaud, *Mémoire sur la nutrition qui a obtenu l'accessit.* Ib. same year. 4to.

Steph. J. P. Housset, on the same subject (in the same school) in his *Mémoires physiologiques et d'hist. naturelle.* Auxerre. 1787. 8vo. t.i. p.98.

or less lax apposition of the nutritious matter, the structure of the similar parts is more or less dense, and the specific weight of the whole body more or less considerable.[i] In this respect, not only individuals, but whole nations, differ from each other. The Yakuts and Burats, who are remarkable for the lightness of their bodies, are a sufficient example of this.

NOTES.

(A) The redness imparted to the bones by feeding animals with madder, does not prove that the matter of the bones is constantly changing; because the opinion that the madder unites with the phosphate of lime in the blood, and thus reddens all the bony matter subsequently deposited, is erroneous. Mr. Gibson proved, by numerous experiments, that the serum has a stronger affinity than the phosphate of lime, for madder. The serum being charged with madder, the phosphate of lime of the bones, already formed, seizes the superabundant madder, and becomes red. If the madder is no longer given to the animal, as it is continually passing off with the excretions, the stronger attraction of the serum draws it from the bones, and they re-acquire their whiteness.[k]

(B) The constant renewal of the epidermis is demonstrated by wearing black silk stockings next the skin. That the hair and nails not only grow perpetually, but are even reproduced, is certain from the great quantity of the former which falls off the head *whole* if worn long, while a good head of hair still continues; and from the renewal of the latter, after the loss of a great part of a finger. I once attended a middle-aged woman, in St. Thomas's Hospital, who had lost nearly the whole of the first phalanx of a finger, and yet the stump was tipped by a nail, though certainly a clumsy one. An instance of a nail at the end of the stump, after the complete removal of the first phalanx,

[i] J. Robertson, *On the specific gravity of living men.* *Philos. Trans.* vol. l. P. i. p. 30. sq.

[k] *Manchester Memoirs,* vol. i.

may be seen in the *London Medical and Physical Journal.*[l] Tulpius declares he has seen examples after the loss of both the first and second phalanges — in secundo et tertio articulo.[m] The glans penis (in truth a mere continuation of the corpus spongiosum urethræ) was entirely renewed in one case.[n] Nothing more can, I apprehend, be said, respecting the entire restoration of organs in the human body. Portions of cutis, bone, membrane, blood-vessels, absorbents, and nerves, are replaced. That portions of large nerves, fully capable of all the functions of the destroyed pieces, are reproduced, is now a matter of certainty. Minute blood-vessels and absorbents are of course allowed on all hands to be produced in the cure of most solutions of continuity, whether by wounds, ulceration, or whatever else;[o] but Dr. Parry, senior, has shown, that in the ram, at least, when a blood-vessel which proceeds some way without giving off a branch is obstructed, new branches sprout forth and establish a communication on each side of the obstruction.[p] The continuance of circulation was previously

[l] 1817. [m] *Observationes Medicæ*, iv. 56.

[n] *Edinburgh Med. and Physical Essays*, vol. v.

[o] Mr. Bauer thinks he has observed vegetable tubes to be constructed by the extrication of carbonic acid gas into a slimy matter prepared for nutrition. Some such opinion was held by Borelli, Tabor, and Hales. He explains the formation of blood-vessels in coagulated fibrin and pus in an analogous manner, but his experiments have not yet advanced far enough for me to dwell upon them. *Phil. Trans.* 1818, and 1819.

Not only divided parts re-unite, but even portions completely separated and cold, and parts of different bodies. A soldier's arm was struck off at the battle of Arlon, with the exception of a piece of skin and the subjacent vessels and nerves, and yet the muscles, bones, &c., completely re-united in about eight months. *Dictionnaire des Sciences Médicales*, t. xii. Garengeot saw a nose unite after being bitten off, trampled upon, and allowed to lie in the dirt till it was cold. *Traité des Operations de Chirurgerie*, t. iii. Dr. Balfour saw a similar occurrence in the instance of a finger. *Edinburgh Med. and Surgical Journal.* 1815. Others might be quoted. See Dr. Thomson's *Lectures on Inflammation*, p. 243.

Transplantation, for instance, of the cock's testes to the hen's abdomen, as well as of the spur to the head, is very common, and the latter was mentioned nearly two centuries ago in Bartholin, *Epist.* Cent. i. p. 174.; and by Duhamel, in the *Mém. de l'Acad. Royale des Sciences*, 1746., as very common in poultry-yards.

[p] *An Experimental Inquiry, &c.* See also Dr. Charles Parry's work, in which similar experiments are related.

attributed solely to the enlargement of the small anastomosing vessels. Muscle is supplied by tendinous matter. The substance formed in the situation of destroyed cellular membrane is so little cellular, that it does not become distended in emphysema or anasarca.[q]

Brutes far surpass man in both the ordinary renewal of the integuments and appendages, and in the extraordinary restoration of destroyed organs. The horse periodically sheds its hair, the bird its feathers,[r] the stag its horns, the serpent its cuticle, the lobster its shell and the teeth which are in its stomach.[s] The fall of the leaves of trees is an analogous circumstance. Insects not only change their coats frequently, but undergo complete metamorphoses, are first worms, then grubs, and finally winged beings. The crystalline lens extracted from an healthy eye is speedily reproduced in cats, dogs, and rabbits,[t] and probably in other brutes. The extraordinary reproductive power of some brutes is almost incredible. A lobster can reproduce a claw, a water-newt an extremity: Blumenbach actually observed the reproduction of the whole head with its four horns in a snail, and the complete eye, — cornea, iris, crystalline lens, &c. in a water-newt.[u] Besides greater powers of reproduction than man, brutes generally possess greater also of reparation — will survive injuries which would prove fatal to us, perhaps under any circumstances, or at least without great care. I related Brunner's numerous attempts upon the life of a dog, of which, violent as they were, "vim elusit, vegetusque evasit," as an illustration of this. Less violent injuries are recovered from with far less danger and inconvenience than we experience. The lower we descend in the scale, the greater tolerance of violence and the greater powers of reparation and renewal do we observe. If the polype, which is a gelatinous tube, with one end closed and the other fringed for

[q] Dr. Thomson, *Lectures on Inflammation*, p. 417.

[r] Feathers which are not cast off, have been discovered to receive an increase of colour at the moulting season. *Linnæan Transactions*. 1818.

[s] This corroborates the propriety of the view taken by Dr. Prout in an unpublished paper written many years ago, in which he contends that the teeth are to be arranged with the integuments. A similar opinion has been lately published in France.

[t] M. M. Cocteau and Le Roy d'Etiolle. Magendie's *Journal de Physiologie*. Janvier, 1827.

[u] *Göttingen Literary Notices*. 1787. p. 28. 30.

the purpose of receiving food and conveying it, is divided, the two halves change at one end, the one closing, the other acquiring fringes, so that both halves become perfect animals; or, if a polype is inverted, the outer surface forms a digesting cavity.

Vegetables endure extreme violence. A log of mulberry-tree has sent forth shoots on being placed in the ground as a post, after many years of neglect; a gooseberry-bush will grow if planted with its branches in the earth and its roots in the air.

SECT. XXXII.

OF THE SECRETIONS IN GENERAL.

466. Besides the nutritious fluids, others of extremely various descriptions are produced from the blood by means of *secretion*, which Haller, no less than his predecessors, with truth and regret declared to be among the most obscure parts of physiology.[a]

467. The secreted fluids differ, on the one hand, so considerably among themselves, and, on the other, have so many points of resemblance, that their classification cannot but be extremely arbitrary. If we arrange them according to the degree of difference between them and the blood from which they are formed, they will stand in the following order.—

First, the *milk*, which may be in some degree considered as chyle reproduced, and appears formed by the most simple process from the blood newly supplied with chyle.

Next, the *aqueous* fluids, as they are commonly denominated from their limpid tenuity, although the greater part differ importantly from water in the nature of their constituents, and especially in the proportion of albumen: such are the humours of the eye, the tears, in all probability the vapour contained in the cellular interstices and the cavities of the abdomen and thorax; nearly similar, also, is the fluid of the pericardium and of the ventricles of the brain.

The liquor amnii of pregnancy, and the *urine*, remarkable for the peculiar nature and mixture of its proper constituents, are generally enumerated among these.

[a] v. Fouquet on Secretion, in the Encyclopedical Dictionary of Paris, t. xiv.
Fr. L. Kreysig, *De secretionibus*. Sp. i, ii. Lips. 1794. sq. 4to.
Ignat. Döllinger, *Was ist Absonderung, und wie Geschieht sie?* Herbipol. 1819. 8vo.

The *salivary fluids*, concerned in mastication, digestion, and chylification, appear more elaborated.

Next the *mucous*, which line the cavities of most of the organs performing the natural and genital functions, and likewise the tract of the nostrils, larynx, and trachea.

The mucus within the eye, and under the epidermis, is nearly similar.

In the same class may be included the cerumen of the ears, the unguent of the Meibomian glands and of the joints, and, perhaps, the ambiguous and nameless fluid commonly poured forth by the vagina during the venereal œstrum.

The *adipose* are, besides the common fat, the medulla of the bones and grease of the skin.

Related to these are the secretion of the corona glandis under the preputium, and of the external female genitals.

The truly *serous*, or albuminous, are the fluid of the ovarian vesicles of De Graaf, and the liquor of the prostate.

The *semen virile* and the *bile* are each sui generis. (A)

468. It is obvious that so great a variety of secreted fluids cannot be secreted from the mass of blood in the same way, nor by similar organs. They differ extremely from each other in the simplicity or complexity of their preparation.

469. The most simple mode of secretion is diapedesis, or transudation: which is the case with the fat and the bony fluid.[b]

[b] Physiologists have lately given different explanations of this mode of secretion. Some assert that every fluid is formed by passing merely through inorganic pores from the blood: others altogether deny the existence of these pores. I think much of this is a verbal dispute. Because, on the one hand, I cannot imagine how *inorganic* pores can be supposed to exist in an *organised* body, for we are not speaking here of the common interstices of matter, in physics denominated pores; and I am persuaded that every opening in organised bodies is of an organic nature, and possesses vital powers exactly correspondent. On the other hand, these openings or pores, which indisputably exist in the coats of vessels, I think but little different in function at least from the cylindrical ducts through which fluids are said to percolate in conglomerate glands and secreting viscera: for this percolation depends less on the *form* of the organ than on its *vital powers*.

Consult, among others, Schreger, *Fragmenta*, p. 37. sq. already recommended.

470. Secretion by *glands*[c] is more complicated. Such is considered the secretion even by follicles and cryptæ, which are found, *v. c.* in some parts of the corium, the fauces, and aspera arteria, and denominated the *most simple* glands.

Properly speaking, the *conglomerate* (as they are called to distinguish them from the lymphatic conglobate) are the only true secreting organs; such as the salivary and lachrymal glands, the pancreas and breasts. They are provided with an excretory duct coming immediately from the large lobes, which are composed of others, smaller, and whose interior structure was once the source of warm disputes in the schools of medicine. Malpighi[d] considered the miliary globules, which are easily discoverable in most glands, as acini, according to his expression, internally excavated. Ruysch, on the contrary, contended that these supposed hollow acini were nothing more than glomerules of blood-vessels, — an opinion shown to be far more consistent with nature by microscopical observation and the effects of minute injection.

471. The structure of some secreting organs, especially of the liver and kidneys, the latter of which strikingly exhibit the glomerules of Ruysch or the acini of Malpighi, are not, excepting in their peculiar parenchyma, very dissimilar from this structure, and indeed throw considerable light upon the question. On the outer part of these, small twigs arise from the sides of the capillary arteries and run into vascular glomerules, hanging from them like granules as from stalks: from these arterial glomerules spring both very minute co-

---

P. Lupi, *Nova per poros inorganicos secretionum theoria refutata*, &c. Romæ. 1793. 2 vols. 8vo.

Kreysig, *Specimen Secundum;* formerly recommended.

Also C. Le Gallois, *Le sang est-il identique dans tous les vaisseaux qu'il parcourt?* Paris, 1802. 8vo.

[c] Sam. Hendy, *On Glandular Secretion.* Lond. 1775. 8vo.

[d] In works repeatedly quoted, and also in his *Diss. de glandulis conglobatis.* Lond. 1689. 4to.

But consult especially his *Opera Posthuma.* ib. 1697. fol.; and published likewise elsewhere.

lourless secreting vessels whose origin from the extremities of arteries was formerly alluded to (92), and the radicles of veins into which the arteries are continued, and which convey back into the venous trunks the remaining blood deprived of the secreted fluid. [e]

472. The organisation of some other secreting parts is evidently peculiar, *v. c.* of the testes, which are composed of very long and numerous vessels, closely compacted, &c.

473. That the different nature of the secreted fluids depends not so much on the size and external form of the secreting organs as upon their interior structure and corresponding vital powers, is rendered probable by the example of many of our fluids, which, although secreted by organs at first sight very different, have considerable resemblance to each other in nature; *v. c.* the saliva and gastric juice. And comparative anatomy teaches us, that the same fluids are formed by organs very different in external appearance, in different animals. [f]

474. We shall now investigate the causes why particular fluids are found in particular organs, — the most difficult part of the doctrine of secretion, and still open to very many doubts.

475. There can be no question that the absolute cause of most secretions is the intimate structure of the secreting organ. This depends, in the conglomerate glands and secreting viscera especially, both upon the peculiar direction and distribution of the extreme blood-vessels, and upon the peculiar *parenchyma* of each secreting organ, in some instances distinguishable at first sight from the substance of every other part. (20)

476. It is likewise probable, and indisputable arguments in favour of the opinion have been continually afforded in the

[e] Al. Schumlansky, *De structura renum.* Argent. 1782. 4to. tab. ii.

[f] Compare, for instance, the form of the kidneys in mammalia with the true conglomerate glands which supply their place in birds; or the pancreas of warm-blooded animals with the pyloric appendices which, although varying in appearance in different fish, secrete a fluid very similar to the pancreatic.

course of this work, that secreting organs have not only a peculiar parenchyma, but a *vita propria* — a peculiar species of vitality distinct from the common vital powers of contractility, irritability, and sensibility.

477. The absorbent system seems to us of much importance in the business of secretion. In every secreting organ, it absorbs, for the purpose of transmission to the blood, a fluid which is, as it were, contaminated by the secretion of the part: *v. c.* a bilious fluid in the liver; a spermatic in the testes.

A constant circle would, therefore, appear to exist in the secretory system, so that the elements of the secretions are incessantly carried to the blood from the secreting organs, and, when they return to the organs, are the more easily attracted by a species of affinity, and draw with them those parts of the blood whose nature is related to their own.

478. The blood, from which some secretions are produced, is endowed with peculiar qualities. The bile, for example, is derived from blood which contains an abundance of carbonaceous element.

479. We omit other assistances afforded to certain secretions; *v. c.* congestion and derivation, so striking in the secretion of milk, &c. (B)

480. There is this difference among the various fluids secreted by the organs and powers now described, — that some pass to the place of their destination immediately, while others are deposited in receptacles, and detained there for a length of time, becoming more perfect before their excretion. The milk in its ducts, the urine, bile, and semen in their respective bladders, and in some degree the serum of the vesicles of De Graaf, are examples of this.

NOTES.

(A) Dr. Bostock arranges the secretions as the *aqueous*, *albuminous*, *mucous*, *gelatinous*, *fibrinous*, *oleaginous*, *resinous*, and *saline*.[a]

The *aqueous* are the perspiration and pulmonary halitus, in which the proportion of water is so great as to give the chief character.

The *albuminous*,—all the membranous or white parts of animals, the fluids of serous membranes and of the cellular membrane, the former differing from the albumen of the blood chiefly in being freed from extraneous matter and coagulated; the latter from serum, chiefly in containing much less albumen.

The *mucous* are the mucus of all mucous membranes, the saliva, gastric juice, tears, and semen. The animal matter which is their basis, much resembles coagulated albumen, and their salts are neutral, while those of the albuminous fluids are alkaline.

The *gelatinous* are named from containing jelly, — a substance not found in the blood nor any of the fluids, but abundantly in membranes, and particularly in the skin; and as albumen may be converted into it by digestion in dilute nitric acid, it appears to be the albumen of the blood with an addition of oxygen. It abounds in the young, so that those parts which at the beginning of life are almost entirely jelly, consist chiefly of albumen as age advances: since it is not found in the fluids, it must be deprived of its oxygen again, and, probably, reduced to the state of albumen.

The *fibrinous* are the muscular fibres, abounding in azote, and thus more completely animalised, resembling the fibrin of the blood, — apparently their source.

The *oleaginous* are the fat, marrow, and secretions of sebaceous glands, and perhaps the milk, as its properties depend so considerably upon oily matter.

The *resinous* are the bile, cerumen, and urea, very similar to the former, but owing their specific characters to a kind of resin. Osmazome, an animal principle in all parts of the body, is referred to this class.

The *saline* are the acids, alkalis, and neutral and earthy salts of the various solids and fluids; generally more copious in the fluids

[a] *An Elementary System of Physiology*, vol. ii. p. 329. sq.

than in the solids, absent in the simple oleaginous secretions, and abundant in the compound; and still more so in the resinous secretions. Their quantity is greatest in the bones, which are principally phosphate of lime; but, with this exception, the urine possesses the greatest proportion, as well as the most variety. 1. In some secretions they are absent; as the fat. 2. In some they exist in definite quantity, and this different from that in the blood; as the saliva. 3. In others, they are found in the same quantity, and of the same nature as in the blood; as the fluid of serous membranes. 4. In some, they are different from the salts of the blood, and of variable quantity; as the urea. These four divisions are, i. The solid albuminous, the gelatinous, and simple oleaginous. ii. The mucous, fibrinous, and compound oleaginous. iii. The liquid albuminous. iv. The aqueous and resinous.

This arrangement is certainly good; but, like every arrangement of natural objects, convenient for general views and memory rather than correct. The semen is mucous, but unlike every other fluid: the gastric juice and cerebral substance are equally *sui generis*. Fibrous matter as well as mucus exists in semen, and is probably, indeed, its specific part: albumen exists abundantly in milk, united into an emulsion with the oleaginous portion. The bile and urine have few properties in common; and urea is certainly not a resinous substance.

Berzelius adopts the old division of secretions and excretions, and makes the following remarks.

"There are two classes of secreted fluids, viz. the *secretions*, properly so called, or the fluids intended to fulfil some ulterior purpose in the animal economy, and the *excretions*, which are directly discharged from the body. The fluids of the former class are all alkaline, and of the latter all acid. The excretions are the urine, the perspired fluid, and the milk. All the other fluids appear to belong to the former class.

"The alkaline secreted fluids may be divided into two very distinct species. The former of these contains the same quantity of water as the blood, so that the change induced by the nervous influence, seems to be confined to that of altering the chemical form of the albuminous materials,[1] without affecting their relative proportion to the water and other substances dissolved in the

[1] This appellation Berzelius gives to the fibrin, albumen, and colouring matter of the blood.

blood. The bile, spermatic fluid, &c. are of this kind. The latter species consists of fluids, in which the influence of the nervous system has separated a large portion of the albuminous matter, and left the remaining liquid proportionally watery. The saliva, the humours of the eye, and the effused serum of membranes, are of this species, and in these the quantity of salts, and in general also of alkali, is the same as in the blood.

" The influence of the chemical agent of secretion is, therefore, chiefly spent upon the albuminous materials of the blood, which seem to be the source of every substance that peculiarly characterises each secretion, each of which is *sui generis*, and is its principal constituent. All the other parts of the secretion seem to be rather accidental, and to be found there only because they were contained in the blood out of which the secretion was formed. Therefore, in examining the secreted fluids, the chief attention should be paid to the peculiar matter of the fluid, which varies in all. This matter sometimes retains some of the properties of albumen, at other times, none; and hence an accurate analysis, showing the quantity and nature of this peculiar matter, is above all to be desired.

" If the several secretions be supposed to be deprived of their peculiar matter and the remainders analysed, the same residue would be found from them all, which also would be identical with the fluid separated from the serum after its coagulation. Thus we should find, first, a portion soluble in alcohol, consisting of the muriates of potash and soda, lactate of soda, and of an extractive animal substance, precipitable by tannin; and secondly, of a portion soluble only in water, containing soda (which acquires carbonic acid by evaporation, and is separable by acetic acid and alcohol) and another animal substance, not extract, precipitable from its solution in cold water, both by tannin and muriate of mercury. Sometimes a vestige of phosphate of soda will also be detected.

" The excretions are of a more compound nature. They all contain a free acid, which is termed lactic, and in the urine this is mixed with the uric acid. Urine seems to contain only a single peculiar characteristic matter; but milk has as many as three, viz. butter, curd, and sugar of milk, which, however, seem to be produced by different organs that mingle their fluids in the same receptacle. The perspired fluid appears to have no peculiar matter, but to be a very watery liquid, with hardly a vestige of the albumen of the blood, and, in short, is the same as the other excretory fluids would be when deprived of their peculiar matter. If we suppose this matter taken away from those excretions which possess it, the remaining fluid will be found to have properties very different from the fluid part of the secretions, when equally freed from their peculiar matter. That of the excretions is acid, contains earthy phosphates, and when evaporated, leaves a much larger residue than the fluid of the secretions. This residue is yellowish-brown, of the consistence of syrup, with an unpleasant, sharp, saline taste of the salt that it contains. It reddens litmus, is most soluble in alcohol, and this spirituous solution contains the muriates of the blood, together with free lactic acid, much lactate of soda (the soda being the free alkali of the blood, neutralised by this acid), and the extractive matter, which always accompanies this neutral salt. The part insoluble in alcohol contains a distinguishable quantity of phosphate of soda, a little of a similar animal matter to that found in the secretions, and also the earthy phosphates which were held in solution by the lactic acid, and were precipitated by the action of the alcohol. The urine possesses also a number of other substances, which will be specified when describing this secretion in particular."[k]

(B) It is of no consequence, in the case at least of some organs, by what vessel the blood is conveyed to the secretory apparatus. Mr. Hodgson, on opening the body of a diabetic person, found the cavity of one renal artery obliterated by an accumulation of atheromatous and calcareous matter in its coats. The glandular structure was perfectly natural. The pelvis contained urine, and a considerable quantity of that fluid was found in the bladder. The kidney was supplied with blood by a large branch from one of the lumbar arteries and by the arteries of the renal capsule.[l] The liver we have seen to have been sometimes supplied by the hepatic artery.

In the next place, some secretions are frequently performed by vessels not destined nor originally employed for their production. Fat accumulates in diseased ovaria, and even the fleshy substance of the heart may be converted into it, as I once saw in a patient of my own. Bone is every day deposited between the inner and

[k] General Views of the Composition of Animal Fluids, by J. Berzelius, M.D. *Medico-Chirurgic. Trans.* vol. iii. p. 234.

[l] *A Treatise on the Diseases of Arteries and Veins, &c.*

middle tunics of the arteries, and the serous membranes are continually ossified. If the kidneys refuse to secrete, urine may be found in the ventricles of the brain, and when there was no outlet for it, an urinous fluid has been furnished by the stomach, intestines, or skin, &c.[m] In the latter cases, it may be said to have been fabricated by the kidneys and discharged by the other vessels, just as the pus of an abscess has sometimes been absorbed and discharged by the kidneys;[n] still we have the singular fact of vessels allowing to stream through them a fluid totally different from that which is natural to them.

Such facts as the ossification of soft parts show that, the blood remaining the same, a new disposition of secreting vessels can change the secretion: and such as ischuria renalis followed by urinary deposition in the brain, that the accumulation of the elements of a secretion in the blood will force healthily disposed vessels to form a new secretion,—that secretion depends importantly upon the state of the blood. The inevitable alteration of every secretion by the irritation of the particular vessels, *v.c.* of the bland mucus of the urethra to a fœtid puriform fluid in gonorrhæa, and of yellow bile, and mild intestinal fluids, to a green, or dark, scalding bile, and fœtid intestinal discharges under the influence of acrid cathartics, are also facts of the former kind; and Dr. Wollaston's observations on the change of the urine of birds to nearly pure uric acid if animal food only is taken, and, above all, the actual appearance of urea in the blood, if the kidneys are removed, so that none can be secreted, are other facts of the latter.[o]

In the case of nutritive secretion, the new substance may pass through pores in the sides of the secreting vessel, or even through the substance, for we have seen that a solution of prussiate of potass in the pleura, and of sulphate of iron in the peritonæum, instantly act upon each other when galvanism is applied; and a

[m] See examples in Haller's *El. Physiol.* l. vii. S. i. § ix. Several such have come to my own knowledge. Mr. Howship attended a lady who discharged many quarts of urine alternately from the bladder and rectum, after intervals of several weeks of suppression, and this for four years without serious injury. *Practical Treatise on Diseases of the Urinary Organs.* 1823.

[n] See Dr. Hennen's *Military Surgery.*

[o] Prevost and Dumas found that the removal of one kidney has no particular effect; but that the removal of both occasions copious vomiting and purging of brown liquid, and death; and 5oz. of blood, yielded ℈i of urea. *Annales de Chimie,* t. xxii.

fluid, as milk, enclosed in a membrane, as a piece of intestine, will pass from it, and water around the exterior be transferred into the cavity when the same agent is employed. But in the case of glandular secretion the new substance is formed in the cavity of the canals and streams along them. Yet in this case, no less than in the other, the change must be chemical. Gelatine is merely oxydised albumen; diabetic sugar, urea deprived of azote and some of its hydrogen; and the labours of Dr. Prout are displaying the various proximate principles of animals and vegetables to have the same elements, and to differ merely in the proportion of component water, or by the presence of a minute proportion of additional substance, hitherto regarded as accidentally present and unimportant. Some substances, it is true, exist in vegetables and animals that cannot at present be entirely ascribed to external sources. Dr. Prout, from most careful experiments, concluded, that there is strong reason to believe that the bones of the chick are not derived from the shell, but from internal production.[p] Vauquelin found the lime of the excrements of hens, and of the shell, to be too great to be ascribed to the food;[q] and the products of plants, fixed in sand and moistened with distilled water, contain so much more carbon and earthy matter than can be supposed to enter them from the atmosphere or the water, that Dr. Bostock and others of our best chemists conceive their existence inexplicable entirely upon these sources.[r] If such is the fact, we may conclude that these substances, though classed, as air and water once were, as elements, because not yet decomposed by chemists, are really not so; for creation is impossible. But although secretion is, I apprehend, merely a chemical process, dependent upon the quality of the blood and aided by the length and diameter of the vessels and other mechanical circumstances, the chemical relations of the various particles, existing quite independently of life, are brought into play — circumstanced so as to become efficient — by the vital powers: how, we know not. But life cannot create any more than it can annul the physical or

[p] *Phil. Trans.* 1822.

[q] *Annales de Chimie*, t. xxix.

[r] See Dr. Bostock's l. c. vol. ii. p. 387. sq. Braconnet concludes that earths, alkalies, metals, sulphur, phosphorus, carbon, and perhaps azote, are thus produced. The immense quantities of calcareous strata, which appear to be the remains of marine animals, are thought referable to organic production only.

chemical qualities of matter. It may counteract one inanimate force by opposing to it another inanimate force; it may render one inanimate force efficient by withdrawing opponent inanimate forces. But this is all; how it accomplishes this, is yet unknown.

Secretion does not depend on the mind, though, like every function, much influenced by it. Fear *increases* the production of urine; any depressing passion will *vitiate* the milk. How far it depends upon nervous influence was considered when speaking of the nervous system.

The formation of the new substance within the vessels may be demonstrated " by forcing coloured injections into the arteries of growing bones, when the lime is seen to issue from their orifices in the form of a white powder, and deposit itself, like the farina of a flower, for the office of consolidation. In a similar way, the injected arteries of the common domestic hen, while her eggs are incomplete, will show the deposition of lime from their exhalant branches upon the membrane which afterwards becomes the shell."[s]

[s] *A View of the Structure, &c. of the Stomach, &c.* By Thomas Hare, F.L.S. 1821. p. 77.

SECT. XXXIII.

OF THE FAT.

481. Of most of the secreted fluids, a concise and connected view of which was given in the last section, distinct mention has been made in its proper place: the rest will be described as opportunity may permit. Two remain, which cannot be discussed more appropriately than at present,—at the close of our inquiry into the natural functions. The one—the fat, is a *part of the system* (4); the other—the urine, is *excrementitious.* We will examine each separately.

482. The *fat*[a] is an oily fluid, very similar in its general character to vegetable oils,[b] bland, inodorous, lighter than water; containing, besides the two elements common to water, to the oils just mentioned, and to wax, *viz.* carbon and hydrogen, sebacic acid,[c] which is pretty similar to the acetic.

483. When secreted from the blood and deposited in the mucous tela, it exists in the form of drops, divided by the laminæ of the tela, in a manner not unlike that in which the vitreous humour of the eye is contained in very similar cells.

484. The relation of fat to different parts is various.

[a] W. Xav. Jansen, *Pinguedinis Animalis Consideratio Physiologica et Pathologica.* Lugd. Bat. 1784. 8vo.

[b] J. D. Brandis, *Comm.* (rewarded with the Royal Prize) *de oleor. unguinosor. natura.* Gotting. 1785. 4to. p. 13.

[c] Joach. J. Rhades, *De ferro sanguinis hum. aliisque liquidis animalium.* Ibid. 1753. 4to. ch. 4.

Dav. H. Knape (Præside Segnero) *De acido pinguedinis animalis.* Ibid. 1754. 4to.

Laur. Crell, *Chemisches Journal.* 1778. P. i. p. 102.

In the first place, some parts, even those whose mucous tela is extremely soft and delicate, never contain fat. Such are the palpebræ and penis.

In very many parts, it is diffused indefinitely, especially in the *panniculus adiposus*, the interstices of the muscles, &c.

In some few, it is always found, and appears to be contained in certain definite spaces, and destined for particular purposes. Such we consider the fat around the basis of the heart:[d] and in the mons veneris, where it forms a peculiar and circumscribed lump.[e]

485. Its consistence varies in different parts. More fluid in the orbit, it is harder and more like suet around the kidneys.

486. It is of late formation in the fœtus; scarcely any trace of its existence is discoverable before the fifth month after conception. (A)

487. There have been controversies respecting the mode of its secretion: some, as W. Hunter, contending that it is formed by peculiar glands; others, that it merely transudes from the arteries. Besides other arguments in favour of the latter opinion, we may urge the morbid existence of fat in parts naturally destitute of it; — a fact more explicable on the supposition of diseased action of vessels, than of the preternatural formation of glands. Thus, it is occasionally formed in the globe of the eye; a lump of hard fat generally fills up the place of an extirpated testicle: and steatoms have been found in almost every cavity of the body. (B)

The glands which some celebrated characters have contended secrete the fat, are only imaginary.[f]

[d] Hence it is clear how many exceptions must be made to the assertion of the celebrated Fourcroy, — that fat is an oily matter, formed at the extremities of arteries, and at the greatest distance from the centre of motion and animal heat. See his *Philosophie Chimique*, p. 112.

[e] I found this still more distinct in the body of a female of the species *simia cynomolgus*, from which, by means of cold, I was able to remove it with its symmetrical form entire.

[f] The singular opinion of the distinguished Home, respecting the origin and use of the fat, *viz.* that it is formed in the large intestines, chiefly by the instru-

Whatever may be the truth of this matter, the deposition and absorption of the fat take place with great rapidity.

488. The use of the fat is multifarious.

It lubricates the solids and facilitates their movements; prevents excessive sensibility; and, by equally distending the skin, contributes to beauty.

We pass over the particular uses of fat in certain parts, *v.c.* of the marrow of the bones.

During health, it contributes little or nothing to nourishment.[g]

The modern opinion has more probability, — that it affords a receptacle for the superfluous hydrogen, which could not otherwise be easily evacuated.[h]

NOTES.

(A) Fat is accumulated under the skin chiefly in the first years of childhood, and again between the fortieth year and old age. Women grow fat earlier, and especially if married.

(B) The intestines occasionally discharge lumps of fat.[i] I have seen several such cases, and some were attended by violent pain.

---

mentality of the bile, and that it supplies a kind of secondary nourishment to the body, will be found fully described in the *Phil. Trans.* 1813. p.146.

[g] P. Lyonet conjectures with probability, that insects destitute of blood derive their chief nourishment from the fat in which they abound. *Tr. anat. de la Chenille qui ronge le bois de Saule,* p.428. 483. sq. and the Preface, p.xiii.

[h] See Fourcroy, l.c.

[i] As some biliary concretions are evidently fatty, and the liver is much disposed to become fatty, it has been thought that these may be of hepatic origin. Abundant references will be found in Dr. Good's *Study of Medicine,* vol. i. p.304.

Yet ambergris is a fatty matter found in the intestines of the spermaceti whale, but never higher than six or seven feet from the anus. Its quantity has exceeded a hundred pounds, and though so frequently discharged as to be found on the shore, and floating on the waves, accumulation, or the state which occasions it, sometimes appears to destroy life. It is more abundant in proportion as the animal is costive and sickly. l. c.

(C) The fattest person on record is, I believe, Lambert of Leicester. He weighed seven hundred and thirty-nine pounds,[k] and died at the age of forty years. In him rats and mice might certainly have nested, if it is true that a Bishop of Mentz, or

> "A Saxon Duke did grow so fat
> That mice (as histories relate)
> Ate grots and labyrinths to dwell in
> His postique parts without his feeling."[l]

Excessive formation of fat may be strongly opposed by regularly taking great exercise, little sleep, and little, but dry, food.[m] Fretfulness of temper, or real anxiety of mind, will prevent any one from getting fat, and make any fat man thin. A passage that occurs in the most magnificent of Shakspeare's Roman plays, and is founded on some information of Plutarch's, will instantly be remembered.

> *Cæsar.* Let me have men about me that are fat;
> Sleekheaded men, and such as sleep o'nights;
> Yond' Cassius has a lean and hungry look;
> He thinks too much: such men are dangerous.
> *Antony.* Fear him not, Cæsar, he's not dangerous;
> He is a noble Roman, and well given.
> *Cæsar.* 'Would he were fatter: — But I fear him not:
> Yet if my name were liable to fear,
> I do not know the man I should avoid
> So soon as that spare Cassius.

Great obesity occurs frequently in infants. I saw a prodigiously fat female, but a year old, who weighed sixty pounds, and had begun to grow fat at the end of the third month. She was also of Herculean general development, and, like most dwarfs, had a flat nose. At an early age I believe females are more commonly the subjects of the affection than males.

[k] Dr. Good says, that some German Journals mention cases of eight hundred pounds weight, but he gives no references.

[l] *Hudibras*, P.ii. Canto i.

[m] Semper vero et certissime debellanda, (obesitas) si modo bona volantas et vis animi fuerit, valida corporis exercitatione, brevi somno, parca et sicca diæta. Nec facile miles gregarius repertus fuerit, qui tali morbo laborat. Gregory, *Conspectus Med. Theor.* lxxxix. Iodine is the best *medicine* against it.

See the instructive case of the Miller of Billericay, in the *Transactions of the Royal College of Physicians, London*, vol. ii.

A large collection of cases of obesity will be found in Mr. Wadd's *Cursory Remarks on Corpulence.*

[n] *Julius Cæsar*, act i. scene 2.

SECT. XXXIV.

OF THE URINE.

489. Besides the nutritious fluids and those which form a part of our system (4), others are superfluous and excrementitious, commonly termed the excrements of the second digestion, and of two kinds. The one exhaled by perspiration, of which we treated formerly; the other — the *urine*, streaming from the kidneys.

490. The kidneys[a] are two viscera, situate at the upper part of the loins on each side, behind the peritonæum; rather flattened; more liable than any other organ to varieties of figure and number;[b] suspended by the emulgent vessels,[c] which are excessively large in proportion to them; and imbedded in sebaceous fat. (485)

491. They are enveloped in a membrane of their own, which is beautifully vascular; and each, especially during infancy, consists of eight, or rather more, smaller kidneys, each of which again consists, as Ferrein asserted, of seventy or eighty fleshy radii, denominated by him pyramides albidæ.

492. A kidney, if divided horizontally, presents two substances; the exterior, called *cortex;* the interior, *medulla.*[d]

Each abounds in blood-vessels, but the cortical portion has

[a] See Al. Schumlansky, l.c.

[b] See Jer. Blasius, *Renum monstrosorum exempla,* at the end of Bellini, *de structura et usu renum.* Amstel. 1665. 12mo.

[c] Eustachius, *tabulæ,* i.—v. which belong to his classical work *De renibus,* published with this great man's other *Opusc. anatom.* Venet. 1564. 4to. also tab. xii.

[d] C. W. Eysenhardt, *De structura renum Observationes Microscopicæ.* Berol. 1818. 4to.

likewise very minute colourless vessels which *secrete* the urine;[e] the medullary part contains those which *carry it off.*

These secreting ducts arise in the manner formerly described (471), from minute arteries formed into glomerules in the cortical part, of which they constitute the greatest portion. They may be readily distinguished by their angular course from the excreting or Bellinian tubes, in which they terminate. These, pursuing a straight course, run from the cortical to the medullary substance, which principally consists of them, and, after they have coalesced into fewer trunks, their mouths perforate, like a sieve, the *papillæ* of the pelvis of the organ.[f]

493. These papillæ usually correspond in number with the lobes which form the kidneys, and they convey the urine, secreted in the colourless vessels of the cortex and carried through the Bellinian tubes of the medulla, into the *infundibula*, which finally unite into a common *pelvis*.

494. The pelvis is continued into the *ureters*, which are membranous canals, very sensible, lined with mucus, extremely dilatable, generally of unequal size in the human subject in different parts,[g] and inserted into the posterior and inferior surface of the bladder in such a way, that they do not immediately perforate its substance, but pass a short distance between the muscular and nervous coats, which at that part are rather thicker than elsewhere, and finally open into its cavity by an oblique mouth. This peculiarity of structure prevents the urine from regurgitating into the ureters from the bladder. (A)

495. The urinary *bladder*,[h] varying in shape according to

[e] These secreting ducts appear to have imposed upon Ferrein as a new description of vessels, which he called neuro-lymphatics or white tubes, and of which he imagined the whole parenchyma of the viscera to be composed. He affirmed that they were of such tenuity, that their length in each kidney of an adult man was equal to 1000 orgyiæ (60,000 feet) or 5 leagues.

[f] Eustachius, tab.xi. fig.10.

[g] See Nuck, *Adenographia*, fig.32. 34, 35. Leop. M. Ant. Caldani, *Saggi dell' Accad. di Padova*, t.ii. p. 2.

[h] Duverney, *Œuvres anatomiques*, vol.ii. tab.i.—iv.

age and sex, is generally capable, in the adult, of containing about two pounds of urine. Its fundus, which in the fœtus terminates in the urachus, is covered posteriorly by the peritonæum. The other coats correspond with those of the stomach.

The *muscular* consists of interrupted bands of fleshy fibres, variously decussated, and surrounding the bladder.[i] These are usually called the detrusor urinæ: the fibres which imperfectly surround the neck and are inconstant in origin and figure, have received the appellation of sphincter.

The *nervous* chiefly imparts tone to this membranous viscus.

The *interior*, abounding in cribriform follicles,[k] is lined with mucus, principally about the cervix.

496. The urine conveyed to the bladder gradually becomes unpleasant by its quantity, and urges us to discharge it. For this purpose the *urethra* is given, which varies with the sex, and will be farther considered in our account of the sexual functions.

497. The bladder is evacuated from the constriction of the sphincter being overcome both by the action of the detrusor (495) and by the pressure of the abdomen. To these in men is superadded the action of the acceleratores, which force out even the drops of urine remaining in the bulb of the urethra.

498. The nature of the *urine* varies infinitely[l] from age, season of the year, and especially from the length of the period since food or drink was last taken, and also from the quality of the ingesta,[m] &c. The urine of a healthy adult, recently

[i] Santorini's posthumous tables, xv.

[k] Flor. Caldani, *Opus.anat.* Patav. 1803. 4to. p.4.

[l] See Hallé, *Mém. de la Soc. de Médecine*, vol.iii. p.469. sq.

[m] The specific quality of some ingesta manifest themselves in the urine so suddenly, even while blood drawn from a vein discovers no sign of their presence, that physiologists have thought there must be some secret ways leading directly from the alimentary canal to the kidneys, besides the common channels. An examination of them will be found in Aug. H. L. Westrumb's Commentary (honoured with the royal prize) *de phænomenis, quæ ad vias sic dictas lotii clandestinas*

made after a tranquil repose, is generally a watery fluid of a nidorous smell and lemon colour, which qualities depend on a peculiar uric substance, besides a variety of other matters [n] held by a large quantity of water in solution, and differing in their proportion to each other in different persons. There is a remarkable quantity of phosphoric acid united with other constituents, forming phosphates of soda, ammonia, and lime. A peculiar acid — the lithic or uric, is found in the urine only. [o] (C)

NOTES.

(A) Mr. Charles Bell has described two long muscles running from the back of the prostate gland to the orifices of the ureters. Their action is not only to assist in emptying the bladder, but to pull down the orifices of the ureters, thus assisting to preserve that obliquity of insertion which the ureters have a tendency to lose in proportion as the bladder is depleted. [p]

(B) Sir Everard Home observed, in his experiments on the spleen, that colouring matters began to manifest themselves in the urine about seventeen minutes after they were swallowed, became gradually more evident, then gradually disappeared, and after some hours, when the mass had unquestionably passed into the intestines, again tinged it as strongly as ever.

---

demonstrandas referuntur. Gotting. 1819. 4to., and P. G. C. E. Barkhausen's Dissertation (which gained the second prize) *de viis clandestinis urinæ.* Berol. 1820. 8vo.

[n] See Fr. Stromeyer, *Theoret. chimie,* t. ii. p. 609.

[o] Consult on the analysis of the urine, among others, Berthollet, *Mém. de l'Acad. des Sc. de Paris,* 1780. p. 10.

Th. Lauth (præs. Spielmann), *De analysi urinæ et acido phosphoreo.* Argent. 1781. 4to.

H. F. Link, *Commentatio* (honoured with the royal prize) *de analysi urinæ et origine calculi.* Gotting. 1788. 4to.

Fourcroy, *Annales de Chimie,* t. vii. p. 180. and t. xvi. p. 113.

C. Fr. Gaertner, *Observata quædam circa urinæ naturam.* Tubing. 1796. 4to.

[p] *Med. Chir. Trans.* vol. iii.

(C) The following is Berzelius's analysis of urine:[q]

Water - - - - -	933.00
Urea - - - -	30.10
Sulphate of potass - - - -	3.71
Sulphate of soda - - -	3.16
Phosphate of soda - - - -	2.94
Muriate of soda - - -	4.45
Phosphate of ammonia - - -	1.65
Muriate of ammonia - - -	1.50
Free lactic acid - - -	17.14
Lactate of ammonia - -	
Animal matter soluble in alcohol, and usually accompanying the lactates - -	
Animal matter insoluble in alcohol -	
Urea, not separable from the preceding	
Earthy phosphates with a trace of fluate of lime	1.00
Uric acid - - - - -	1.00
Mucus of the bladder - - -	0.32
Silex - - - - -	0.03
	1000.00

Like the blood, urine affords carbonic acid gas under the receiver of an air-pump,[r] and more after a meal.[s]

It is a common mistake, even at present, to ascribe, as Blumenbach does, the colour and smell of urine to the urea, which is now known to be colourless, and to have an extremely faint, and by no means urinous, smell. Dr. Prout has established that urea consists of

Hydrogen - - -	.266
Carbon - - -	.799
Azote - -	1.866
Oxygen - - -	1.066
	4.000[t]

[q] *Med. Chir. Trans.* vol. iii.

[r] Vogel, *Annales de Chimie,* t. xciii.

[s] Mr. Brande, *Phil. Trans.* 1810.

[t] *Med. Chir. Trans.* vol. viii. p. 535.

The large proportion of azote in the urea, leads to the conclusion that the kidneys are the great outlet for azote, as the lungs and liver are for carbon.

Dr. Prout procured from uric acid a curious substance which he denominates the purpuric acid.[u]

The urine of birds is generally discharged with the fæces, and becomes solid by exposure to the air. That of serpents is discharged only once in some weeks, is of a caseous consistence, and likewise becomes perfectly solid afterwards. Both are urate of ammonia.[x] The urine of the turtle and tortoise is also destitute of urea, but does not contain urate of ammonia so pure. The analysis of the urine of brutes is highly interesting, but not yet either extensive or accurate. Dr. Wollaston found the uric acid to be only $\frac{1}{200}$ part in a goose feeding on nothing but grass; and in birds taking nothing but animal food, to constitute nearly the whole mass.

In disease no urine has sometimes been secreted for twenty-two weeks.[y] Dr. Richardson mentions a lad of seventeen who had never made any, and yet felt no inconvenience.[z]

[u] *Phil. Trans.* 1818.
[x] Dr. Prout, *Thomson's Annals of Philosophy.* Dr. Davy, *Phil. Trans.* 1818.
[y] Haller, *Biblioth. Medic.* vol. ii. p. 200.
[z] *Phil. Trans.* 1713.

SECT. XXXV.

OF THE GENERAL DIFFERENCES OF THE SEXES.

499. ALTHOUGH the functions hitherto examined are common to both sexes, some are performed very differently in each. The most prominent differences shall be briefly reviewed before examining the sexual functions, properly so called.[a]

500. In general, each sex has its peculiar *form;* more or less striking after birth, but not very obvious in the young fœtus; for the genitals of the male and female, at this period, are not at first sight different, on account of the clitoris being remarkably large[b] and the scrotum scarcely formed.[c] (A)

[a] Melch. Sebiz, *De differentiis corporis virilis et muliebris.* Argent. 1629. 4to.

F. Thierry E. *præter genitalia sexus inter se discrepant.* Paris. 1750. 4to.

Dictionn. Encycloped. (Yverdon edit.) vol. xviii. art. Femme, and vol. xlii. art. Viril.

J. Fidel Ackermann, *De discrimine sexuum præter genitalia.* Mogunt. 1788. 8vo.

The same writer's *Historia et ichnographia infantis androgyni.* Jen. 1805. fol. p. 61. sq.

P. Roussel, *Système physique et moral de la Femme.* 2d edit. Paris. 1803. 8vo.

Ad. F. Nolte, *Dissertat. sistens momenta quædam circa sexus differentiam.* Gotting. 1788. 8vo.

J. Louis Moreau de la Sarthe, *Histoire naturelle de la Femme.* Paris. 1802. 3 vols. 8vo.

Autenreith, *Archiv. für die Physiol.* t. vii. p. 3. sq.

[b] Langguth, *Embryo 3½ mensium qua faciem externam.* Viteb. 1751. 4to.

James Parsons, *Phil. Trans.* vol. xlvii. p. 143.

Morgagni, *De sedibus et causis morborum.* xlviii. 10.

[c] This I lately found confirmed in twin abortions of different sexes and of about sixteen weeks' formation, in which, although they were most beautifully and correctly made, the difference of the genitals was not at first discoverable. In every other respect, — in the general figure, physiognomy, the dimensions of the loins, &c., they were perfectly similar.

501. During infancy, the general figure is but little different, but becomes more so as age advances, when the round and plump breasts, the general conformation, the delicacy, softness, and the proportionally low stature of the female, form a striking contrast with the sinewy and robust body of the male. [d]

502. The relation of parts, in well-formed females, is somewhat different from that in the male. For instance, in the female the face is proportionally smaller; the abdominal and lumbar portion of the trunk longer; the hips broader, not, however, if well formed, broader than the shoulders; the buttocks larger; the legs in their descent gradually approach each other towards the knees. (B)

503. A similar difference is remarkable in the osseous system. In females, the bones are, cæteris paribus, smoother and rounder, the cylindrical more slender, and the flat thinner; to pass over individual differences, *v. c.* the very slight prominence of the frontal sinuses, the more elliptic edges of the alveoli, the greater narrowness of the chest, the greater capacity on the contrary of the pelvis, the difference of the clavicles, thigh bones, &c. [e] (C)

504. With respect to the soft parts, the female mucous tela is more lax and yielding, so as to dilate more easily during pregnancy; the skin is more delicate, and of a clearer white, from the quantity of fat below it.

The hair of the head is commonly longer: but other parts, which are covered with hair in men, are either quite smooth

[d] Consult, besides our great countryman Alb. Dürer, *Vier Bücher von menschlicher Proportion*. Nurenb. 1528. fol. the two celebrated male and female figures, painted by Titian, or one of his school, in Vesalius's *Epitome suor. libror. d. c. h. anatome*. Basil. 1542. fol.

Also the three delineated by that excellent artist, Jer. Laidresse, in Bidloo, tab. i, ii, iii.

And Girardet's figures in the *Cours complet d'Anatomie gravé par* A. E. Gautier, *et expliqué par* M. Jadelot. Nantes. 1773. large fol.

[e] I have described these differences more fully throughout the skeleton, in my *Osteological work*, p. 87. sq. 2d edit.

Compare Sömmerring's *Tabula sceleti fœminei*. Francof. 1796. fol. with the male figure in B. S. Albinus's *Tabulæ sceleti*, tab. 1.

in women, as the chest and chin; or less hairy, as the perinæum; or smaller in circumference, as the pudenda; or covered with merely a very delicate and soft down, as the arms and legs. (D)

505. Among the particular differences of function, must be mentioned the pulse, which is, in females, cæteris paribus, more frequent (116); and the quantity of blood passing to the abdomen is greater. The lungs, on the other hand, are smaller, from the greater narrowness of the chest, which is however more moveable above. The os hyoides is much smaller; the larynx scarcely prominent and more contracted, whence the voice is less grave.

506. As to the animal functions, besides the greater abundance of nerves in the organs of *generation*, the general nervous system of females is far more mobile, and their liability to emotion stronger. On the other hand, the muscular system is weaker, and the muscles (with the exception of the glutei, psoæ, quadrati lumborum, and a few others) proportionally smaller. (E)

507. In regard to the natural functions, the stomach and the appetite for food are less;[f] the growth of the body more rapid; and the periods of dentition, puberty, and full growth, earlier.

508. But by far the greatest difference exists in the genital functions, which are intended in man for impregnating, and in woman for conceiving. The fuller investigation of these now remains to be prosecuted. (G)

NOTES.

(A) Sir Everard Home has published a singular hypothesis.[g] He suggests that the sex is not determined at the first formation

[f] Hence genuine and indubitable cases of long abstinence from food have generally occurred in females. (F) See, among many others, Fl. James Voltelen, *Diatr. memorabilem septennis apositiæ historiam exhibens.* Lugd. Bat. 1777. 8vo.

[g] *Phil. Trans.* vol. lxxxix.

of the individual, but that the parts of generation are originally so situated, and of such a nature, that they are capable of becoming either male or female organs when the sex is subsequently fixed. His arguments are the following.—1. The testes and ovaria lie originally in the same situation. 2. The clitoris is at first of great size. 3. When the female among brute mammalia has inguinal mammæ, so likewise has the male; men also possess breasts. 4. The scrotum occupies in the male the place occupied in the female by the labia, and is of the same structure with them. 5. The nymphæ of the female exactly correspond to the preputium of the male. 6. Twins are usually of the same sex, as if the same cause had influenced the generative organs of each; when they are of different sexes, it is a common remark that they seldom breed, nature probably having been disturbed in her operations. 7. When among black cattle twins are produced of different sexes, that which appears the cow is really an imperfect hermaphrodite, possessing a mixture of incomplete male and female organs, sometimes, for instance, having testicles in the place of ovaria, sometimes four substances, looking like testes and ovaria, is incapable of breeding, and vulgarly termed a free martin; —a circumstance in every respect analogous to the preceding.[h] It may be added, that the round ligaments of the female descend, like the two spermatic chords of the male, to the abdominal ring; that marsupial bones exist, without any function whatever, in the males of some marsupial animals; that the hen has a bursa Fabricii; and that the glans clitoridis of the female opossum is bifid. Comparative anatomy furnishes many similar facts. But the existence in both sexes of parts which can be useful only in one,—confessed by Paley to have been a complete puzzle to him,[i] is now universally regarded as merely an instance of Nature's observance of general rules in the formation of beings:[k] even some

[h] J. Hunter, *Observations on Certain Parts of the Animal Economy*, p. 55.

[i] *Natural Theology*, c. 25. p. 472.

[k] "It shows in the function of generation an union of the *teleological* and *mechanical* principles, which were formerly thought to be incompatible with each other." In one sex we have "a clear instance of the teleological principle, *i. e.* a peculiar part formed for a certain purpose." In the other sex, "where the end and purpose of the part do not exist, we have the mechanical principle; as if the part had been merely framed in compliance with some general model for the structure of the species." Blumenbach, *Comparative Anatomy*, c. ii. § 38.

species of animals have parts that are useful only in others. The resemblance of the scrotum to the labia, and of the nymphæ to the preputium, and the original identity of the situation of the testes and ovaria, may be similarly explained. The usual identity of the sex of twins still shows only Nature's general plans, and the frequent infecundity of twins of different sexes, together with the circumstances of the free martin, even when of that description in which testes are substituted for ovaria, shows only that general plans have been somehow thwarted.[l] And it must be remembered, that if testes are occasionally substituted for ovaria in the free martin, an attempt is sometimes made to produce *both* testes and ovaria, a fact not explicable on the supposition of a substance capable of becoming *either* testes or ovaria.

Mr. Knight considers that the sex of the offspring is determined by the female rather than by the male. He observed that individual cows, &c. however various the males, produce one sex rather than the other, so that he has with tolerable certainty predicted the number of male and female young; while nothing similar was ever observable in regard to his bulls, rams, &c. Even the external appearance and the habits of brutes and vegetables, he has found much more, and sometimes altogether, influenced by the female. The quantity of pollen employed in the fecundation of female plants, he found of no importance in this respect.[m]

But M. Girou de Busareingue, from repeated and extensive experiments, has lately ascertained that, whatever may be the influence of particular individuals, the age of the male, among sheep and horses, has a very great general influence upon the sex. The younger the males, the greater the number of females produced, and *v. v.* The better also the mothers were fed,

---

Such parts are peculiarly called *vestiges*; some consider the os coccygis the vestige of a tail; the odorous glands of the human genitals are vestiges of what are really useful in brutes.

[l] This writer's hypothesis reminds me of one that prevailed among the Greek and Arabian physicians (Galen, Avicenna, Ægineta, Rhases), who asserted that the male and female organs differed in situation only; that the structure was originally the same, but that when the constitution had a good degree of heat, the parts protruded, and a male was formed; whereas when the temperature was low, they were not excited, and remained within, giving the female sex.

[m] *Phil. Trans.* vol. xcix.

the greater the number of females and twin births.[n] The stronger also the mother, and the more in her prime, the greater the number of females; the weaker from any cause, or if she was below or beyond her prime, the more males were produced. This was noticed also among cows.

(B) The form as well as the texture of the female is more delicate: her surface has no muscular protuberances, but is beautifully rounded; her legs, therefore, have no calves, but, like the arms and fingers, gently taper; her feet and hands are small; her stature one sixth shorter than that of the male; her neck longer. From the smaller stature and the greater size of the abdominal and lumbar regions, it follows that the middle point which lies at the pubes in the male, is situated higher in the female. Her abdomen is more prominent and rounded, and her shoulders stand less forward and distant from the trunk. Her thighs are more voluminous and distant from each other.

(C) The greater capacity of the female pelvis, which contains the chief organs of generation and affords a passage for the child, arises from the greater expansion of the ossa ilei, the larger angle of the junction of the ossa pubis, and the greater concavity and breadth of the os sacrum: the os coccygis likewise is more slender and moveable. The clavicles are less bent; the thorax more projecting, whence deeper, although narrower and shorter; the sternum shorter and broader; the cartilago ensiformis shorter; the two superior ribs flatter. Camper remarks, that if the male and female forms are traced within two ellipses of equal dimensions, the male shoulders will stand without and the pelvis within, while the female shoulders will remain within and the pelvis without.[o] The face and brain are absolutely smaller than in men, the face likewise proportionally so; yet such is the relative size of the cranium, that, while in the male the head, including the teeth, is as 1 to 8 or 10, in the female it is as 1 to 6, of the weight of the rest of the skeleton.

(D) Hen birds have a far less beautiful and copious plumage than cocks.

An instance is related by M. Roux of a woman forty years of age, who had one child, and whose breasts were well developed,

[n] *Journal de Physiologique*, t. vii.

[o] *Mémoire sur le beau Physique.*

having a strong and long beard: the lobes of her ears were also covered with hair.[q]

(E) Inferior to man in reasoning powers and corporeal strength, woman possesses more sensibility of both body and mind, more tenderness, affection, and compassion, more of all that is endearing and capable of soothing human woes, but less firmness of character, except indeed where affection subsists;—although *Varium et mutabile semper fœmina*, is a true character, yet nothing is too irksome, too painful, or too perilous, for a mother, a wife, or a mistress, to endure or attempt for the object of her love.

> "A thousand acts in every age will prove
> Women are valiant in a cause they love.
> If fate the favour'd swain in danger place,
> They heed not danger, — perils they embrace,
> They dare the world's contempt — they brave their name's disgrace.
> They on the ocean meet its wild alarms,
> They search the dungeon with extended arms,
> The utmost trial of their faith they prove,
> And yield the lover to assert their love."
>
> Crabbe, *Tales of the Hall*, xxi.

The head of the female is as different from that of the male as her mental character. It is altogether smaller. The forehead is smooth, from its various parts being equally developed; full above the nose; narrower, but of only moderate height, and gently retreating: the inferior parts of the sides and occiput are small (amativeness, destructiveness, combativeness); but the development immediately above is proportionally considerable (philoprogenitiveness, adhesiveness, secretiveness); the summit of the head is proportionally high (veneration).[r]

(F) And beastly gluttons are generally men.

(G) All the Linnæan classes of vegetables whose sex is known, are hermaphrodite, excepting Diœcia and in part Polygamia. Some inferior animals also are naturally hermaphrodite; and among others, for instance, moths, eels, carp, crabs, monstrous hermaphrodites are not uncommon, each half of the body possessing the characteristics of a different sex. There probably exists

[q] *Anatomie descriptive*, par Xav. Bichat, t. v.

[r] See a delightful paper upon the female character by Mr. W. Scott, in the *Phrenological Journal*, No. vi. art. 17.

no authentic account of a true hermaphrodite,[s] capable of impregnating and being impregnated, among mammalia. Yet,

[s] Hermaphroditus was the son of Mercury and Venus,—Hermes and Aphrodite, who, while bathing in a fountain of Caria, smote the heart of its presiding nymph, Salmacis. He rejected her intreaties, and she, endeavouring to obtain her wishes by force, closely embraced him, and implored the gods to make them one body; her prayers were heard, and the characteristics of each sex were preserved.

Mercurio puerum diva Cithereïde natum,
Naïdes Idæis enutrivere sub antris.
Cujus erat facies, in qua materque paterque
Cognosci possent: nomen quoque traxit ab illis.

Ovid, *Metam.* l. iv.

Formerly, the existence of true hermaphrodites was not doubted. In Winrich (*de ortu monst.* c.20.), Riolan (*de hermaphr.* c.8.), and Shenkius (*Obs. Med.* 575.), we read of a maid servant who, in 1461, was condemned to be buried alive for having got her master's daughter with child. Montuus declares that he knew an hermaphrodite, supposed to be a female, who had brought her husband several children, and was in the habit also of intriguing with females. Sanchez, the celebrated Jesuit casuist of Cordova, in the 17th century (*Disput. de sancti Matrimonii Sacramento*, cvi.), determines that an hermaphrodite should adopt the predominant sex, or, in case of equality, choose one and adhere to it, nor be allowed to marry till this is done. The Jewish and Canon law treat of hermaphrodites, and Lord Coke says (lib. 1. § 1. fol. 8. of fee simple), every heir is male, female, or hermaphrodite, *i. e.* both male and female, and "an hermaphrodite, which is also called an androgynus, shall be heir as male or female, according to the kind of sex which doth prevail, and accordingly ought to be baptized." The ancients thought them ill omens (Cicero, *de divinatione*), and drowned them. Eusebius says, that the Christian emperor, Constantine, once ordered them for destruction, because the Nile did not overflow so much as usual. For much learned information, see Dr. Parsons *On Hermaphrodites.*

When there is no combination of the organs of both sexes, a little variety has frequently given rise to a mistake in the sex. If the septum of the scrotum is narrow, each half may so closely surround the testis as to give an appearance of labia. If, at the same time, the urethra terminates before it reaches the extremity of the penis, and especially if the testes are ill developed,—a circumstance very common in this malformation, the feminine appearance is much augmented. As smallness of the testes is often accompanied by want of the constitutional male characters,—beard, prominent larynx, grave voice, and broad shoulders, and in these circumstances the female character of broad hips, breasts, &c., more or less appear, a superficial observer may easily mistake the sex of such persons. A deficient development, or total absence, of the testes, may be attended by all these general effects, without malformation of the scrotum or urethra. The malformation of the scrotum just mentioned, together with smallness of the penis, has sometimes occasioned a mistake of the sex till the period of puberty, when the true sex has become evident, and the individual been imagined to have changed occasionally, brutes of this class have perfect organs of one sex, combined with imperfect ones of the other; [t] and both they and the human subject each set imperfect, so as to be, though in various proportion to each other in different cases, *neutrumque et utrumque.* [u] Nor that in such combinations in the human subject

---

his sex. Ambrose Paré mentions a Marie Germain, who had been always thought a girl; but, while she was leaping over a ditch one day at puberty, a penis suddenly disclosed itself and proved her to be a lad. Montaigne also mentions him (*Essais*, 1. 20.), and another to whom the same fortune happened while playing in bed with a female. Livy and Shenkius have recorded many such. In the *Journal de Med. Chir. et Pharm.* 1816, a young man is said to have passed for a female all his life, and was on the point of marrying with another young man, when his parents, being aware of something wrong in his construction, and that he had never menstruated, determined on a previous medical examination. The doctors pronounced him (Mary) a male; he instantly burst into tears (so much had friendship all along taken the place of love), and exclaimed, that then she should lose her *bon ami*. His dress and register were changed by order of the authorities, and he was very nearly made a soldier.

On the other hand, with a bulky clitoris, which is common in the Mandingo and Ibbo nations, especially if accompanied by coherent labia, or by no labia, an opening at the same time existing under it and leading to the urethra and vagina, a female may be carelessly mistaken for a male: but the clitoris is imperforate, and has no preputium at the lower part, and, consequently, no frænum; and a probe passes at once into the bladder, whereas in ambiguous males, it has far to go. (Dr. Baillie, *Morb. Anat.*)

We thus see the origin of the stories in Virgil and Ovid of Cœneus (*Æneis* VI.), and Scytha (*Metam.* II.), whom Ausonius Gallus knew to be quite unnecessary to establish the fact:

> Nolo tamen veteris documenta accersere famæ;
> Ecce Ego sum factus fœmina de puero.
>
> Zacchias, *Quæst. Med. Leg.* p.496.

On a person so metamorphosed, Bauhin made the verse—

> Mas, mulier, monachus, mundi mirabile monstrum.

[t] In the *Phil. Trans.* 1799, Sir Everard Home describes a bull which had begot five calves, and possessed ordinary male organs, and had the general appearance of the male, except in the flanks and hind quarters, but which had an udder and teats affording milk, and a small vagina, incapable of admitting the male organ.

[u] See a human instance in Dr. Baillie's *Morbid Anatomy.* The general aspect was masculine, except that no beard existed. There were breasts, a clitoris, and meatus urinarius of the natural female appearance; but a vagina only two inches long, and terminating blindly, and no nymphæ; labia very long, and each containing a body feeling like a testicle. Menstruation had not occurred. In the *Medical Repository* an adult is said to be described of general masculine aspect, having in the left groin a small scrotum containing a testicle, and on the other side a

at least one testis and one ovarium now and then exist, do I at all doubt, after reading the case given by Maret, [x] and seeing the creature shown here lately under the name of Lefort. In the former, a testicle on one side and an ovarium on the other are decidedly said to have existed, besides vesiculæ seminales, a Fallopian tube, an uterus, a blind vagina, and a blind penis: from

---

labium; a vagina and hymen, or at least a small opening existed, and the urethra resembled the female; but the clitoris was $2\frac{1}{2}$ inches long, when not erect, and had a groove below as if for a male urethra: menstruation had not occurred, nor sexual desires been experienced.

M. Petit (*Mém. de l'Acad. des Sciences,* 1729, p. 29.) has described the generative organs of a soldier, who died of his wounds. The penis is not mentioned, and therefore probably was normal, but the scrotum was destitute of testes, and there was a blind vagina communicating with the urethra. Two testes were discovered in the usual situation of the ovaria, possessing vasa deferentia, which passed as usual to vesiculæ seminales. There was also a prostate gland. This person might have performed the part of a male bedfellow, but unfruitfully from the termination of the urethra in the vagina, unless such means could be successfully employed as are mentioned in John Hunter's *Treatise on the Venereal Disease.*

Analogous cases of spurious hermaphrodism among brutes are the free martins of black cattle already mentioned. (p.414.) In two, John Hunter found imperfect testes in the situation of the ovaria, and in a third were both testes and ovaria lying together. In an hemaphrodite ass he also discovered substances resembling both testes and ovaria. Sir Everard Home has described a similar dog, which had long been a favourite in Lord Besborough's family, and had never been in heat. "There was not the smallest appearance of teats on the skin of the belly; so that in this particular it differed both from the male and female; nor was there the least trace of any thing like the gland of the breast under the skin. The clitoris was very large, being one-third of an inch long, and one-half of an inch broad; the orifice of the meatus urinarius was uncommonly large, as if it was intended for a common passage to the bladder and vagina, so that the external parts were only the clitoris, meatus urinarius, and rectum. Internally, in the situation of the ovaria, were two imperfectly-formed small testicles, distinguished to be such by the convolution of the spermatic artery; from these passed down an impervious chord, or vas deferens, not thicker than a thread, to the posterior part of the bladder, where they united into one substance, which was nearly two inches long, and terminated behind the meatus urinarius. The other parts of the animal were naturally formed. When the testicles were cut into they appeared to have no regular glandular structure." *Phil. Trans.* 1799.

Haller describes a very similar kid: the imperfect testes were in the same situation. There was likewise a canal or vagina, which divided like the uterus into two horns, extending to the testes. There were also vesiculæ seminales.

[x] *Mém. de l'Acad. de Dijon,* t. ii. See also a remarkable case in the *New York Medical Repository,* vol. xii. p. 86.

the middle upwards the general characteristics of the female were conspicuous, and from the middle downwards those of the male. Lefort had the general characteristics of each sex. The relative proportion of the trunk and extremities, that of the shoulders and pelvis, and the conformation and dimensions of the latter, were those of the male; the chin had as good a beard, and the breasts and extremities were covered with as abundant hair, as we usually observe in fair young men of the same age. Yet there were beautifully formed breasts with perfect areolæ and nipples, the hands and feet were small, and, like the other portions of the extremities, most elegantly tapering. Its unforeseen departure from London deprived me of the advantage of a second interview, but I thought that the voice, face, cranium, and mental character were a mixture of those of both sexes. I could not have said, on seeing such a face only, whether it belonged to a man or a woman. The eyes certainly sparkled with desire. Now had this been a man with imperfect organs, there might indeed have been the characteristics of the female more or less marked, but certainly not those of the male; and vice versa: nor would the eyes in either case have expressed the warmth of passion. On this account I am disposed to believe it in possession of at least one testis and one ovarium. The best judges in Paris pronounced it a woman; the best in London, a man. With respect to the genitals, I own myself to have been disinclined to examine them at a first interview, but learn there was a small clitoris — with an imperforate gland, and an urethra running along it inferiorly (a structure perhaps unknown in monstrous formation of simply female organs), and opening underneath by five small holes.[y] A passage existed at the foot of the clitoris into which a catheter passed, but which afforded no urine. The catheter introduced into it might be directed downwards behind a membrane that united the labia below — where the opening of the vagina is commonly found, and would probably be divided with advantage, as the menses come through this passage. In fact both they and the urine pass through it and the five holes of the canal that is under the clitoris, and the urine is reported to come through both, although the catheter could bring none, and neither passed into the bladder nor excited a desire to make water, if introduced into the lower canal. Whence there is probability in the con-

[y] *Dictionnaire des Sciences Médicales,* Art. Hermaphrodisme.

jecture, that the urethra communicates with this passage within, by similar openings to those observed externally in its lower part.

Lefort has been seen to menstruate, and those who have not inspected the pudenda when visiting it at this period, have declared the countenance to be pale and languid as in a menstruating woman. It boasts of having menstruated ever since eight years of age, of having desires for each sex, and of being able fully to enjoy both. But a little exaggeration of this kind must be expected. The attendant told me that it had kept a young French girl some years. Whether seminal discharge takes place, is doubtful, as the communication between the testes (if there are any) and urethra may be deficient in some point. That it can derive any pleasure from sleeping with a male, except in the general contact, is impossible. On the contrary, the membrane that unites the labia must prevent coition and render every approach of the male organ extremely painful. No wonder, therefore, that, though its habits are feminine (it does needle-work), perhaps in some measure from confinement, it has chosen a girl for its associate. Independently, however, of these circumstances, I do not suppose that Lefort's beard and disgusting hairiness of breasts and limbs would easily procure a *cavalier servente*.

This is a good opportunity for speaking of malformation in general.

In the important points of our frame the same plan is pretty steadily followed; but in indifferent particulars Nature is so far from uniform that she appears delighted with variety. We are seldom disappointed in expecting the natural structure of the spine, great vessels, or important viscera; but it is not very uncommon to find the brachial artery dividing near the axilla, the obturatrix arising from the epigastric, the palmaris or plantaris muscle wanting, the biceps having an additional slip from the os humeri, or the latissimus dorsi from the angle of the scapula, or the spleen accompanied by one or more little ones. These merit the name of *varieties* only, and in the arrangement of minute blood-vessels, the length of bony processes, and other little insignificant matters, there exists so much uncertainty that it would be difficult to say which is the natural structure. In truth, were we all alike, there would be the confusion of indistinguishableness. The existence of small moles can hardly be deemed even a variety; large ones may be considered such. Deviations of a more striking and uncommon character are called *lusus naturæ*. Such are, the absence of colouring matter in the hairs and in the cutis and iris in Albinoes (XLIV. last note); spots and patches of white in the skin of piebald negroes; and of brown and black, often seen with tufts of hair, in truth, very large hairy moles, in whites; a peculiar colour of the whole or a portion of one iris, of the eyelashes of one eye, or of some of the hair of the head; the cuticle of the porcupine family (p. 179); the course of the vena portæ to the inferior cava, without distribution in the liver (p. 336); the malformations of the heart in the morbus cœruleus (p. 155); the situation of the heart on the right side,[z] and the general transposition of the thoracic and abdominal viscera; oval irides; irides entirely deficient under the centre of the pupil; a bifid uvula, the two parts sometimes very distant, and the soft palate deficient above; a bifid glans penis, with two fræna; the termination of the urethra behind the glans, or in the vagina; a double uterus; deficient vagina; deficiency of tendinous parietes of the abdomen, so that a connate ventral hernia exists; a supernumerary, whole or partial, thumb or toe: an instance of each of which, and of several more than one instance, I have myself seen, (with the exception of the unusual course of the vena portæ, and with the exception of the heart, &c. and uterus,) in the living subject. If the deviation among visible parts is still more considerable, and, indeed, though it be much less than those of invisible parts, but, by being obvious, greatly disfigures, it is termed a *monstrosity*. Such was the deficiency of the upper extremities from below the shoulders in Miss Biffin, whom most frequenters of English fairs have seen, and of the arms and legs in Marc Catozze,[a] the Venetian, whose hands were attached to his shoulders, and his feet to his hips or thighs; absence of the radius and ulna on one side, between the os humeri and hand, or of one or more metacarpal bones; absence of the front of the bladder and abdominal parietes, so that the ureters terminate and discharge urine externally; or of the phalanges; or an additional forearm and hand; are not so rare but that I have seen them also in

[z] I saw an instance of this in the museum at Edinburgh; it occurred also at the Hotel Dieu. (Winslow, *Mém. de l'Acad.* 1743.) See three cases in Shenkius, p. 310.

[a] *Eccentric Mirror*, vol. ii.

the living subject.[b] Zacchias saw a globular head upon the clavicle without the intervention of a neck.[c] Extreme hairiness of the skin, such as described at p. 180, is a monstrosity; the skin may be considered as covered by a hairy mole; the absence of gastrocnemii is a lusus naturæ.[d] Similar aberrations from Nature's usual course out of the animal kingdom were designated *ostenta*, *portenta*, *prodigia*,[e] from the notion of their being ominous; whence the opinion of Cicero is highly probable that these aberrations in the forms of human beings are called *monstra* from the superstition of their pointing out something that will happen; not, as Licetus[f] contends, because they are shown as sights. Whatever may have been the reason of the appellation, it clearly implies something visible, obvious to all; which circumstance is the reason that mere degree of deviation does not constitute a monster, and that visible disfigurement is requisite to the idea; whence the definition of the most learned Zacchias, — "an animal formed *enormously* different from the goodness and simplicity of *figure* belonging to its species."[g]

Varieties, lusus naturæ, and monstrosities, may all be arranged accordingly as they are *excesses*, *deficiencies*, or *misplacements*. To

[b] I think I saw an additional head at the side of the other in a human fœtus, both at Edinburgh and Vienna, and once I witnessed this in a living calf. In the Hunterian museum are the two skulls of a child, that was the son of a native farmer in the East Indies, and lived to be four years old. The additional one was placed upside down on the top of the other. Each contained a brain, invested by its own dura mater, and the upper received its blood from the lower. The features of the upper head were sometimes unaffected, when the lower head cried, and were never affected when it smiled. The gums of both were cut by front teeth. When the nipple was presented to the upper head, it made a slight attempt to suck. The tears of the upper head constantly ran over, but especially when the lower head cried. The eyes of the upper head would open on a sudden impression, but even then, as well as at all other times, were directed to no object. They remained open during sleep. The mouth of the upper head showed signs of gratification when the lower sucked. The upper head had much less sensibility. (*Phil. Trans.* vol. lxxx. and lxxxix.)

Winslow saw in 1698, an Italian with an additional little head, attached by the lower half of the right side of the face and cranium, to the thorax, below the cartilage of the third rib; it had been separately baptized, and the man felt if it was touched. *Mem. de l'Acad. des Sc.* 1733.

[c] l. c. De monstris.

[d] Three cases will be found in M. Paletta's *Exercit. Patholog.*

[e] *Ostendere, portendere, prædicere.*

[f] *De monstris.*

[g] l. c.

this classification of monsters by Buffon,[h] *unnatural formations* are added by Blumenbach,[i] as a part may be monstrously formed, although neither excessive, defective, nor misplaced.[k]

Buffon's arrangement relates to whole organs; but were it applied to portions of them also, Blumenbach's fourth class would be exceedingly small. For instance, the first illustration given of it by Mr. Lawrence, is when the anterior part of the urinary bladder and corresponding integuments are absent, the ossa pubis not conjoined, and the posterior part of the bladder projecting between the recti abdominis muscles, forming, " by its mucous lining, a soft, red, sensible protuberance on the lower part of the abdomen, contiguous at its circumference with the common skin, with the ureters opening upon it, and constantly allowing a free passage to the urine." Now this is really a case of deficiency as far as respects the bladder and integuments, and of misplacement as respects the ossa pubis and recti muscles. Spina bifida, again, is in fact an example of deficiency. Another instance adduced is a single cyclopic eye in the middle of the forehead, — a monstrosity which is a misplacement of each eye, for the organ is plainly always two united; or of an union of the two kidneys into one. The propriety of applying these subdivisions to deviations of portions as well as of the whole of organs is proved by the occasional deficiency or redundancy of portions only, *v. c.* when the arm between the shoulder and hand, or only the front of the urinary bladder, is absent. The hare-lip, which is often accompanied by a cleft in the palate also ; the termination of the rectum in the bladder or vagina, or its termination without an opening; a bifid glans penis : — fairly belong to this fourth subdivision, they being instances neither of excess, defect, nor misplacement, but of unnatural structure.

Few cases are unmixed. Defect, excess, or misplacement, are often, sometimes indeed necessarily, combined with unnatural structure: and not unfrequently excess, defect, and unnatural structure, all make up the derangement together.

There may be different kinds of deviation in different parts of

[h] *Histoire Naturelle*. Supplement. t. iv. p. 578.

[i] Although these arrangements are intended only for monsters by Buffon, and the more striking malformations by Blumenbach, they may be applied to all deviations.

[k] *Handbuch der naturgeschichte*, s. ii. The arrangement is followed by Mr. Lawrence, *Med. Chirurg. Trans.* vol. v.

the same subject, and it is worthy of notice that considerable deviations are generally accompanied by minor ones of other parts. Spina bifida and club feet very frequently co-exist. When the brain is absent, so that the fœtus has no forehead and looks like a cat (called in Germany *katzenkopf*), there is often something wrong about the extremities or the viscera of the trunk; and absence of heart is always, according to Mr. Lawrence, ac-accompanied by considerable deviations in other parts.

The highest degree of deviation may combine the extremes of more than one of the four subdivisions, and sometimes presents a being very like a brute. In old books we read of women bringing forth dogs, pigs, monkeys, nay, even lions, elephants,[l] and fish,[m] and even little devils with hoofs, claws, horns, tail, and a black skin,[n] since intercourse of this kind was two centuries ago thought common enough, and monsters were ascribed to it.

As an instance of the lowest degree of unnatural structure, I may mention a minute opening in the lachrymal sac on the side of the nose of a young lady whom I know: the highest degree is perhaps instanced in the malformations of the heart. The lowest degree of misplacement is exemplified when a testis is placed for life in the groin: the highest is perhaps witnessed in the transposition of the viscera.[o] The lowest degree of defect is instanced in the absence of the gall-bladder: the highest, where only the lower half of the trunk with the lower extremities, or only one extremity, exists. In excess the addition may be merely attached, or may be mingled with the same part into one larger. The highest degree of excess is where a second fœtus is attached. Zacchias saw

[l] Shenkius, *Obs. Med.* 691.

[m] Roederer, *Dissertation couronnée à Petersbourg.*

Licetus, *De Monstris*, with plenty of plates, shows what can be done in the way of incredible cases.

[n] After many learned examples of women loved by brutes and devils, to which monsters were formerly ascribed, Burton gravely declares, "Many divines stiffly contradict this, but I will conclude with Lipsius, that since examples, testimonies, and confessions of those unhappy women are so manifest in this our town of Lovan, it is likely to be so. One thing I will add, that I suppose in no age past (I know not by what destiny of this unhappy time) have there ever appeared or showed themselves, so many lecherous divels, satyrs, and genii, as in this of ours, as appears by the daily narrations and judicial sentences upon record." *Anatomy of Melancholy*, 3. 2. 1. 1.

[o] Mr. Lawrence refers to five examples of this, and some of the subjects were adults, and one lady died at 72 years of age.

at Rome, in 1617 and 1623, a well-formed handsome boy, named Lazarus Coloreto, to whose chest there grew another, with only one leg, and that too short, mutilated arms, a hideous face, a thick head unable to take food, perpetually dribbling, and with no sense but that of touch, which he showed by moving himself when hurt, and who had been christened John Baptist.[p]

[p] The poor people very consistently thought he must have a soul as well as Lazarus, and so baptized him. Zacchias disapproves of this, and very reasonably, as the brain showed no intelligence; being compelled to measure mind solely by cerebral power, and, seeing none, to conclude that John Baptist had no soul. Yet though this was reasonable, it was very inconsistent with his belief in soul, since, according to it, John Baptist's case was exactly like that of all idiots: — A soul existed, but merely because the brain—the instrument it had to play upon, was bad, its operation was prevented. Zacchias, who was chief physician at Rome to the ecclesiastical states, extricates himself from the difficulty as cunningly as the Jesuits did when publishing Newton's doctrine as a mere hypothesis. "Latis a summis pontificibus contra telluris motum, decretis nos obsequi profitemur," said they. "Ecclesiæ Catholicæ, in hoc et in cæteris omnibus, humiliter me subjicio," says Zacchias. (l. c. vii. 1. 4—17.) The manifestation of mind must determine whether a monster should have the rights of a human being, and its parents those of fruitful spouses. Without some mind, it cannot live at all after separation from the mother, unless attached to another; but should it have no more sense and volition than is sufficient for breathing, it ought not to be destroyed. Two women, one a midwife, were prosecuted at York for drowning a child with deficient cranium, that would probably have lived but a few hours or days. The judge expressed a hope that the prosecution would prove the erroneousness of the vulgar opinion, that the law allows the life of any human being to be taken away by another. In catholic times, all monsters were destroyed without ceremony, as the offspring of the devil.

Montaigne saw a boy exactly fourteen years old, who had a headless brother fixed front to front, looking "as if a small child was endeavouring to embrace a bigger." The place of union was below the breasts, and about the extent of four fingers, so that "if you lifted up the imperfect child, you saw the other's navel." (*Essais*, ii. 30.) Winslow saw attached to the body of a well-formed girl, twelve years of age, the abdomen and lower extremities of another smaller than herself. It discharged fæces, and she felt when it was touched. Winslow was consulted upon the propriety of administering extreme unction to it as well as its sister. (*Mém. de l'Acad. des Sciences*, 1733.) If it had a soul, Van Helmont was right in placing the soul in the abdomen. A male pelvis with lower extremities attached to the pubes of a well-formed Gentoo boy, are described in the *Phil. Trans.* lxxix. The lad had no power over his burthensome piece of a brother, but felt if it was touched. In the medical journals for 1821, is an authentic case of a lad in China, sixteen years of age, named Ake, who had a brother growing to the pit of his stomach, without a head, so that this attached brother seemed as if he had run his head into Ake's body. Whatever part of this was

Where there is no great difference in the size of the two beings, the case can hardly be styled an excess, or at any rate either party has an equal right to consider the other the exuberance. Such were the Hungarian sisters mentioned by Blumenbach (78), who were united at the back below the loins. All the viscera were double; but the recta and vaginæ of both formed one common opening. The aortæ and inferior cavæ also united. They menstruated, evacuated, felt hungry, slept, and were ill at different times, but of course died together.[q] One was rather stronger than the other, and dragged her sister with her when they wished to go in contrary directions, and they sometimes quarrelled when one only wished to retire; but fortunately Judith and Helen were extremely fond of each other. They attained the age of twenty-one.

One of the most extraordinary compound monsters is described by M. Mannoir, of Geneva,[r] and the subject is preserved in our Hunterian Museum. The two children of which it was composed may be fancied to have been divided transversely, and the two upper halves united at the cut part, and the two lower likewise, and then the two compound pieces laid across each other.

The additional being is sometimes not united in this way, but contained in a cyst, and attached to the exterior of the other. A perfect child was born in Devonshire, 1746, with a tumour attached to the sacrum, containing the rudiments of a fœtus.[s]

The second child, thus encysted, is occasionally placed internally, and may at last cause serious inconvenience. At Genoa,

---

touched, Ake said he felt as if the same in his own body was touched, and really, on the narrator pinching the little one's hip while Ake was looking the other way, Ake instantly turned about and clapped his hand upon his own hip. When Ake made water the little one always did the same. A similar case was lately published in the second volume of the *Medico Chirurg. Trans.* of Edinburgh, in which the perfect brother could discharge urine at pleasure from his pendulous brother. Many other such cases are recorded.

[q] The following epigram, related by Petrarch, was inscribed on stone figures of a similar pair, christened Peter and Paul.

Non vero nobis unus somnusque cibusque
Nec risus nobis, fletus et unus erat.
Unus membra dabat somno ridebat et alter,
Surgebatque unus, flens quoque et alter erat.

F. Petrarch, *De Rer. Mem.* iv. 6. 21.

[r] *Med. Chir. Trans.* vol. vii.

[s] *Phil. Trans.* vol. xlv. p. 325.

in 1699, a boy, fourteen years of age, had a perfect fœtus taken from his abdomen, through an opening made in a very large tumour just above the umbilicus, that had been increasing from his birth.[t] A girl, five years old, born at Dangerhorst, proved to have in her abdomen all the distinct parts of a fœtus.[u] The Medical and Chirurgical Society has published the case of a boy in whose abdomen was a cyst, containing all the rudiments of a fœtus; and of a girl, two years and a half old, who had a large tumour in the left side, occasioned by a cyst with parts of a fœtus.[x] A boy who had reached his fifteenth year in good health, was found to bear in his abdomen a pretty large imperfect female fœtus, by Mr. Highmore, in Dorsetshire.[y] A boy, fourteen years of age, was some years ago discovered after death, at Paris, to have the rudiments of a fœtus in his abdomen;[z] and in the last century one at Tours.[a] A girl at Naumburg became such a kind of a mother in eight days from her birth.[b] A male greyhound is said to have voided a live whelp per anum, at Chester in 1695.[c] An egg has sometimes been contained within another.[d]

Of the same nature as these are perhaps certain cases, in which hair and sebaceous fat, and frequently teeth, are found collected. The hair has no roots, and occasionally is in immense quantity, the greater part making a compact ball, and the rest immersed in the fat. The teeth are generally molares, and have no fangs. The usual seat of these collections is the ovaria, but then it is the ovaria of virgins. A case lately occurred, in which the mass was situated in the anterior mediastinum of a young woman, twenty-one years of age, and consisted of serous fluid, hair, fat, two cuspidati, two incisores, and three molares, a portion of bone resembling the superior maxillary, and alveolar processes around

[t] Said to be related in the *Thesaurus Med. Chir. Observat. curios. Leipsiæ*, 1715.

[u] Said to be related in Lieutaud's *Observ. Med.* fasc. 1. 1760.

[x] 1809 and 1815.

[y] *Case of a fœtus*, &c. 1815.

[z] Corvisart's *Journal*, t. ix. *Gazette de Santé*, No. 1. 1804. *Saltz. Med. Chirurg. Zeitung*, 1804. 4. B. 290.; all referred to by Plouquet as for three different cases.

[a] *Journ. de Med.* 1755.

[b] *Dict. des Sciences Méd.* Cas rares.

[c] *Phil. Trans.* xix. p. 316.

[d] Grew, *Rarities*, p. 18. *Phil. Trans.* xix. p. 632. *Gentleman's Magazine*, xvii. p. 573.

several of these teeth.[e] Such a mass has been situated in the loins of a gelding;—probably in a testis which had not descended.[f]

Monstrous formations are frequently discharged prematurely. Autenreith observes "that he found three abortions monstrous out of nineteen whose parts could be distinguished; that Wrisberg met with two among five; and Ruysch two in twelve:—altogether seven to twenty-nine."

Sömmerring states that most monstrous abortions are of the male sex.

A sound offspring is frequently born at the same time with a monstrous production, and monstrous productions occasionally alternate with well-formed children.

Sometimes one unusual formation only occurs in a large family; sometimes several, and perhaps in immediate succession.

These circumstances show, as Duverney, and immediately after him Winslow, contended about a century ago (*Mem. de l'Acad. des Sc.* 1743), that monstrosity generally arises from original faulty formation, or rather faulty powers in the ovum, and not from subsequent injury. How far the mind can influence the formation we will consider in the section on the nisus formativus.

[e] *Med. Chir. Trans.* London, 1825. vol. xiii.

[f] Baillie's *Morbid Anatomy.*

SECT. XXXVI.

OF THE GENITAL FUNCTION IN MAN.

509. The male genital fluid is produced by the two testicles, which hang in the scrotum, by their *spermatic chords*, through a ring called abdominal, or through, more properly, a fissure in the tendon of the external oblique muscle of the abdomen. (A) Besides abundant lymphatics, three orders of vessels are found in the testes.—

The *spermatic artery*, which is, in proportion to the fineness of its calibre, the longest artery, by far, in the system, and usually conveys blood to the testicle immediately from the abdominal aorta.

The *ductus deferens*, which carries to the vesiculæ seminales the semen secreted from the arterial blood.

The *pampiniform plexus* of veins, which return to the cava or renal vein the blood remaining after secretion. (B)

510. The testes are not originally suspended in the scrotum. In the very young male fœtus, they are placed in a very different part, and the nature and successive changes of their situation that were first accurately investigated by Haller,[a] but have since been variously stated, have given rise to numerous controversies.[b] I shall derive my account of this subject from the natural appearances which I have preserved in a great number of small embryos, dissected by me with this view.

[a] Haller's Program. *de herniis congenitis,* reprinted in his *opusc. patholog.* p. 311. sq. vol. iii. Opera minora.

[b] C. J. M. Langenbeck, *Commentatio de structura peritonæi, testiculorum tunicis eorumque in scrotum descensu.* Gotting. 1817. fol.

B. W. Seiler, *Observationes de testiculorum ex abdomine in scrotum descensu.* Lips. same year. 4to.

511. On opening the lower part of the abdomen of a young fœtus, there appears in each groin, at the ring of the oblique muscles, a very small opening in the peritonæum, leading downwards to a *narrow passage* which perforates the ring and runs to a peculiar sac that is extended beyond the abdominal cavity towards the scrotum, is interwoven with cellular fibres, and destined for the future reception of the testicle.

512. At the posterior margin of this abdominal opening, there is sent off another process of peritonæum, running upwards, and appearing, in the young fœtus, little more than a longitudinal fold, from the base of which arises a small cylinder, or rather an inverted cone, that terminates above in a globular sac, containing the testis and epididymis, so that the testis, at first sight, resembles a small berry resting on its stalk, and appears hanging, like the liver or spleen, into the abdomen. (399)

513. The vessels, which afterwards constitute the spermatic chord, are seen running behind the very delicate and pellucid peritonæum; the spermatic artery and vein descending along the sides of the spine, and the vas deferens passing inwards, in the loose cellular substance behind the peritonæum, towards the neck of the bladder. They enter the testis in the fold of peritonæum just mentioned.

514. After about the middle period of pregnancy, the testis gradually descends and approaches the narrow passage before spoken of (511), the fold of peritonæum and its cylinder becoming at the same time bent down, until it lies directly over the opening of the passage.

515. The testis being now ready for descent, the opening, which was hitherto small, becomes dilated, so as to allow the organ to pass it, the abdominal ring, and the whole passage, and to descend into the bulbous sac (511); after this occurrence, the opening soon becomes strongly closed and even grows together, leaving scarcely any vestige of itself in infancy.

516. In proportion to the slowness with which the testis

proceeded towards the opening, does its transit through the abdominal passage appear rapid, and, as it were, instantaneous. It is common to find the testis in mature fœtuses either lying over the peritonæal opening, or, having passed this, resting in the groin; but I have once only met with the testis, and then it happened to be the right and in a twin fœtus, at the very time when it was adhering, and in a manner strangled, in the middle of the passage, being just about to enter the sac; in this instance, the left testis had passed the abdominal canal and was already in the sac, and the abdominal opening of the same side was perfectly closed.

517. This remarkable passage of the testis from the abdomen through the groin is limited to no period, but would seem to occur generally about the last month of pregnancy; the testicles are found, however, not very rarely in the abdomen or the upper portion of the groin at birth. For they have always another part of their course to finish, after leaving the abdomen, viz. to descend, together with their sac, from the groin into the scrotum.

518. Repeated observation demonstrates this to be the true course of the testicles. To assign the *powers* and *causes* of its accomplishment is no easy matter. For I am every day more convinced that neither of the powers to which it is usually ascribed, viz. the action of the cremaster or diaphragm, or the mere contractility of the cellular membrane, interwoven with tendinous fibres, that exists in the cylindrical process of peritonæum (512), and is called the Hunterian *gubernaculum*, is sufficient to explain so singular a movement, and least of all to explain the transit of the testis through the passage so often mentioned; but that the whole affords, if any thing does, a striking illustration of a vita propria, without the peculiar influence of which, so remarkable and unique a course, similar to no other function of the system, cannot even be imagined. (C)

519. The coats of the testes, after their descent, are conveniently divided into *common* and *proper*.

The common is the *scrotum*, consisting of the skin having a very moderate substratum of fat, and differing from the rest of the integuments in this, — that it is continually changing its appearance, being sometimes lax and pendulous, sometimes (especially during the venereal orgasm and the application of cold) constricted and rigid, and in the latter case, singularly marked by rugæ and furrows.[c]

520. With respect to the coats proper to each testis, the *dartos* lies immediately under the scrotum, and is endowed with a peculiar and strong contractile power, which deceived the celebrated Winslow, Haller, &c. into the belief of the presence of muscularity. (D)

521. Next to this, with the intervention, however, of much soft cellular substance, are found three orders of *tunicæ vaginales;*[d] viz. an exterior, *common* to the testis and spermatic chord, and to which the *cremaster* muscle adheres by disjointed bundles of fibres.

And two interior, one *proper* to the chord, and one to the testis; the latter of which usually adheres by its fundus to the common coat, but is internally moistened, like the pericardium, by a lubricating fluid. (E)

522. The origin of these vaginal coats, — the subject of so much controversy, may, I think, be readily explained, from the circumstances, already mentioned, attending the descent of the testis.

The coat *common* to the testis and chord arises from the descending bulbous sac or peritonæal process. (511)

The *proper* coat of the *testis*, from that production of the peritonæum which, ascending from the cylinder (512), originally invests the testis.

The coat *proper* to the *chord*, from that fold and short

[c] Besides the assertion that the scrotum differs strikingly from the rest of the integuments in being reproduced after its destruction by gangrene; although many careful observers declare this reproduction, as it is termed, to be very imperfect, and even imaginary. See v. c. Stalp. v. d. Wiel. cent. 1. p. 364. Quirot, *Mém. de l'Acad. de Chirurg.* t. iv. p. 97.

[d] J. E. Neubauer, *De tunicis vaginalibus testis et funiculi spermatici.* Giess. 1767. 4to.

F. L. Eichhorn, *De hydrocele.* Gott. 1809. 4to.

cylinder of the peritonæum in which the fold terminates before it surrounds the testicle. (F)

523. To the body of the testis[e] there adheres very firmly, like the bark of a tree, a coat called *albuginea*, through the combination of which with the internal part of the vaginal coat, blood-vessels penetrate into the *pulpy substance* of the testis.[f] This pulpy substance is entirely composed of innumerable vessels, about a span in length,[g] and convoluted into lobules, both conveying blood and secreting semen,[h] the latter of which is carried, through the rete vasculosum of Haller[i] and the vasa efferentia of de Graaf, to the apices of the cones of the epididymis.[k]

524. The *epididymis*, lying on the side of the testicle and consisting of one vessel about thirty feet in length, is divided into about twenty glomerules or cones at the part called its head,[l] and is continued into the vas deferens, at its lower part, which gradually becomes thicker[m] and is denominated its tail.

525. Each *vas deferens*, ascending towards the neck of the urinary bladder and converging towards the other under the prostate gland, is then directed backwards and dilated into the vesiculæ seminales, in such a manner, that the common mouth both of the vesicles and vasa deferentia opens into the urethra, behind the caput gallinaginis.[n]

526. The *vesiculæ seminales*, which adhere to the posterior and inferior surface of the bladder, surrounded by an

[e] Alex. Monro, fil. *De testibus et de semine in variis animalibus.* Edinb. 1755. 8vo.

[f] B. S. Albinus, *Annotat. Acad.* l. ii. tab. vii. fig. 1, 2, 3.

[g] Vide Grew, *Museum Regalis Societatis,* p. 7.

[h] The celebrated Sömmerring was so successful as to inject all the vessels composing the testis, and the entire head of the epididymis, with mercury. *Ueber die körperl. Versch. des negers vom Europäer,* p. 38.

[i] Haller, *De viis seminis* in the *Phil. Trans.* No. 494. fig. 1. *g. g.*

[k] De Graaf, *De Viror. organis generationi inservientibus.* tab. iv. fig. 1, 2.

[l] Vide Alex. Monro, fil. *Observations, Anatomical and Physiological.* Edinb. 1758. 8vo. tab. i. E. E. E. F. G. H.

[m] B. S. Albinus, *Annotat. Acad.* l. ii. tab. iii. fig. 1.

[n] B. S. Albinus, l. c. l. iv. tab. iii. fig. 1, 2, 3.

abundance of fat, resemble two little intestines winding in various directions and branching into numerous blind appendices.

They consist of two coats, nearly similar to those of the gall-bladder: the one strong, and of the description usually termed nervous; the other interior, delicate, abounding in cells, and divided into compartments by prominent ridges, like those found in the cervix of the gall-bladder. [o]

527. In these passages is slowly and sparingly secreted and contained after puberty, the *semen*, a very extraordinary and important fluid, of a milky yellowish colour, [p] of a peculiar odour, of the same viscidity as mucus, and of great specific gravity, of greater indeed than any other fluid in the body. [q]

528. Semen has also this peculiarity, first observed by Lewis Hamme of Dantzic, in the year 1677, [r]—of being animated by an infinite number of small worms visible by the microscope, of the kind denominated infusoria, [s] and of different figures in different genera of animals. In man, [t] these *spermatic animalcules* are oval and have very fine tails: they are said to be found in prolific semen only, so that they are in some degree an adventitious criterion of its prolific maturity; we say adventitious, because we hope, after so many weighty arguments and observations, [u] there is no necessity

[o] See, besides, the figures by Graaf, Haller, Albinus, and Monro, ll. cc. especially the beautiful one by Fl. Caldani, in his *Opusc. Anat.* p. 17.

[p] The opinion of Herodotus respecting the black semen of Ethiopians, refuted in ancient times by Aristotle, has, to my surprise, been taken up in modern times by Le Cat, de Pauw, Wagler, &c.

[q] F. B. Osiander asserts, "that fresh semen emitted under certain circumstances, is occasionally *phosphorescent.*" *De causa insertionis placentæ in uteri orificium.* Gotting. 1792. 4to. p. 16.

[r] Vide Fr. Schrader, *De microscopior. usu in nat. sc. et Anatome.* Gotting. 1681. 8vo. p. 34.

[s] *Handbuch der Naturgesch.* p. 506. 10th edit. tab. i. fig. 13.

[t] W. Fr. v. Gleichen, *Uber die Saamen-und Infusionsthierchen.* Nurenb. 1778. 4to. tab. i. fig. 1.

[u] Consult especially Laz. Spallanzani, both in his *Opuscoli di fisica animale e vegetabile,* Milan. 1776. 8vo. vol. ii., and in his *Dissertazioni,* &c. Ibid. 1780. 8vo. vol. ii.

at present to remark, that they have no fecundating principle, and much less are the germs of future offspring. (G)

529. The genital fluid gradually collected in the vesicles is retained for subsequent excretion, and by its stay experiences changes nearly similar to those of the bile in the gall bladder, — becoming more inspissated and concentrated by the removal of its watery portion.[x]

530. For as the whole of the testis and spermatic chord abounds in lymphatic vessels, which carry back to the blood a fluid with a seminal impregnation and thus facilitate the secretion of semen in the manner before described (477); so the vesiculæ seminales are likewise furnished with a similar set of vessels, which, by absorbing the inert watery part, render the remaining semen more powerful.

531. But I very much doubt whether genuine semen is ever absorbed during health; still more that it ever passes, as is sometimes asserted, into the neighbouring veins; and most of all, that by this absorption, if it does occur, unseasonable venereal appetites are prevented, since, if we compare the phenomena of animals, procreating at particular periods, with the constitution of those which are castrated, we must conclude that this absorption is rather the cause of ungovernable and almost rabid lust.

532. We conceive that this end is accomplished in a very different mode, by a circumstance which occurs, as far as we have been able to discover, in no animal but man, — by *noc-*

[x] A paradoxical opinion was formerly entertained by some, — that the semen is not discharged from the vesiculæ seminales but from the vasa deferentia, and that the fluid of the vesicles is not truly spermatic and derived from the testis, but of quite another kind, and secreted in peculiar glands belonging to the vesicles. This has gained some advocates among the moderns. J. Hunter, *On certain parts of the Animal Economy*, p. 27.

J. A. Chaptal, *Journal de Physique*. Febr. 1787. p. 101.

But it has been refuted by Sömmerring, in the *Bibliotheca Medica*, which I edited, vol. iii. p. 87. (H)

Add the remarkable instances of men and other male animals possessed of vesiculæ seminales, that have discharged prolific semen after complete castration.

Consult, among others, the distinguished Elliotson in his English translation of these *Institutions*, p. 329. 3d edit. 1820.

turnal pollutions, which we regard as a natural [y] excretion intended to liberate the system from the otherwise urgent superfluous semen, more or less frequently, according to the variety of temperament and constitution. [z]

533. The semen is never discharged pure but mixed with the *prostatic fluid*, which is very much of the appearance of the white of egg, and has acquired its name from the organ by which it is produced, — an organ of some size, of a peculiar and very compact texture, lying between the vesiculæ seminales and the bulb of the urethra, and commonly denominated *prostate gland*. The passages for the course of this fluid are not well known, unless perhaps they communicate with the sinus of the seminal caruncle, the orifice of which opens into the urethra [a] between the two mouths (525) of the seminal vesicles.

534. The male *urethra* is the common outlet of three different fluids, — the urine, semen, and prostatic liquor. It is lined with mucus which proceeds from numerous sinuses dispersed along the canal. [b] We find it surrounded by a spongy texture, upon which lie two other *spongy bodies* [c] of much greater thickness, constituting the major part of the penis.

[y] Ch. R. Jaenisch, *De pollutione nocturna*. Gotting. 1795. 4to.

Aug. Gottl. Richter, *Specielle Therapie*, vol. iv. p. 552. sq.

C. W. Hufeland, *Abhandl. der Königl. Akademie der Wissensch. in Berlin*, 1819. p. 170.

[y] I willingly grant that barbarous nations, of a phlegmatic temperament and copulating promiscuously, do not require this excretion; but I must contend that it is a perfectly natural relief in a young man, single, sanguineous, full of juices, with a strong imagination, and living high, although enjoying the completest health.

[a] Morgagni, *Adversar. Anat.* iv. fig. 1, 2.

[b] J. Ladmiral, *Effigies penis humani*. LB. 1741. 4to.

[c] Ruysch, *Observat. anat. Chirurg. Centur.* p. 99. fig. 75—82.

And his *Ep. problemat.* xv. fig. 2. 4. 6, 7.

T. H. Thaut, *De virgæ virilis statu sano et morboso*. Wirceb. 1808. 4to. fig. 1.

The distinguished Home has clearly and faithfully displayed this truly cellular or spongy texture of the cavernous bodies of the penis, that was lately in general confounded with the blood-vessels in which it abounds. *Phil. Trans.* 1820. P. ii. p. 183. sq.

The penis is terminated anteriorly by the *glans* — a continuation of the spongy texture, and usually covered by a delicate and very moveable skin, which is destitute of fat, and, at the corona of the glans, forms the preputium, and freely moves over the gland, nearly as the eyelids do over the eyeball. The internal duplicature of the preputium, changing its appearance, is reflected over the glans, like the albuginea of the eye, and is beset at the corona with many Littrian [d] glands, similar to the Meibomian of the eyelids and secreting a peculiar smegma. [e]

535. The virile organ, thus constructed, possesses the power of *erection*, — of becoming swollen and stiff and changing its situation, from the impetuous congestion and effusion [f] of blood into its corpora cavernosa either by corporeal or mental stimulus, and of detumifying and collapsing after the return of the blood. [g] (I)

536. When in a flaccid state, it is considerably bent at its origin from the neck of the bladder, [h] and thus perfectly adapted for the discharge of the urine, but quite unfit for the

[d] Morgagni, *Aversar. Anat.* 1. tab. iv. fig. 4. *i. k.*

[e] This smegma in young men, especially when they are heated, is well known to accumulate readily and form an acrimonious caseous coagulum. The inhabitants of warm climates are particularly subject to this inconvenience, and the chief use of *circumcision* appears to be the prevention of this accumulation. We know that for this reason Christians, in the scorching climate of Senegambia, occasionally cut off the preputium, and that uncircumcised Europeans residing in the east frequently suffer great inconvenience. Guido de Cauliaco, the celebrated restorer of surgery in his day, who flourished in the middle of the fourteenth century, said that circumcision was useful to many besides Jews and Saracens, " Because there is no accumulation of sordes at the root of the gland, nor irritation of it." *Chirurg.* Tr. vi. doctr. ii. p. m. 111.

[f] Vide Theod. G. Aug. Rooze, *Physiologische Untersuchungen.* Braunsv. 1796. 8vo. p. 17.

[g] A phenomenon worthy of remark, even from the light which it promises to throw on this function in general, is the erection so frequently observed in those who are executed, especially if strangled.

Consult, besides Garmann's compiled farrago (*de Miraculis Mortuorum,* I. xi. 7 sq.)

Morgagni, *De sed. et caus. morb.* xix. 19 sq. (K)

[h] See Camper, *Demonstration. anat. pathologic.* L. ii. tab. iii. fig. 1.

emission of semen,[i] because the beginning of the urethra then forms too acute an angle with the openings of the seminal vesicles.

537. When the penis swells from desire, the prostatic fluid generally flows first, and indeed is often discharged pure, though rarely together with the urine: its principal use is to be emitted with the semen and by its albuminous lubricity to correct the viscidity and promote the emission of this secretion.

538. The emission of semen is *excited* by its abundance in the vesicles and by sexual instinct; it is *effected* by the violent tentigo which obstructs the course of the urine, and, as it were, throws the way open for the semen; by a kind of spasmodic contraction of the vesiculæ seminales; by a convulsion of the levatores ani[k] and of the acceleratores urinæ; and by a succussion of the whole system, short and less violent, though almost of an epileptic nature and followed by depression of strength.[l] (L)

NOTES.

(A) Instances of more than two testes are extremely rare. Three, four, and even five, are said to have existed, and several authors declare that they themselves have seen three in individuals many of whose families were equally well provided.[m] Unless such cases are related by an experienced medical man from his own observation, they deserve no credit, and even then must be regarded with suspicion, if anatomical examination or the peculiar pain of pressure have not proved the additional bodies to be analogous to testes no less in structure than in form and situation. The

[i] Gysb. Beudt, *De fabrica et usu viscerum uropoieticorum.* LB. 1774. 4to. reprinted in Haller's Collection of Anatomical Disputations, t. iii. tab. iii.

[k] Carpus in Mundinum, p. 190[b] and 310.

[l] For which reason Zeno, the father of the Stoic philosophy, called the loss of semen the loss of part of the animating principle. (M)

[m] Dionis, *L'Anatomie des corps humains.* Demonstration quatrième. Sect. 1. Fernelius, Forestus, De Graaf, Borelli, &c. &c. Shenkius has collected several examples.

late eccentric Dr. Mounsey, who ordered that his body should either be dissected by one of his friends or thrown into the Thames, was found to have in his scrotum a small steatom, which during life might have given the appearance of three testes.

The writers of such wonderful cases completely disagree in their account of the powers of these triorchides, tetrorchides, and pentorchides, some asserting them to be prodigious, others greatly below those of ordinary men.

One testis is commonly larger than the other, and, the right spermatic chord being for the most part shorter than the left, the right testis is generally the higher.

(B) The original situation of the testes accounts for the circumstance of their blood-vessels arising from the loins, as John Hunter remarked; for parts generally derive their vessels from the nearest source. The same applies to their nerves. Hence, too, the right spermatic artery frequently springs from the right renal as being nearer than the aorta, and the left spermatic vein frequently pours its blood into the left renal as being nearer than the inferior vena cava.

The original situation of the testes accounts also for the circumstance of the vas deferens arising from the lower part of the epididymis and bending upwards; in the fœtus this is not the case, but it is the necessary consequence of the subsequent change in the situation of the testes.[n]

(C) The descent of the testes into the scrotum must, I apprehend, be owing to the growth of their nerves and vessels, and to the direction afforded by the contraction of the gubernaculum; the growth of the former, and therefore the whole process, is accounted for in the minds of some by the contraction of the latter.[o] Mr. Hunter's original account of the gubernaculum may not be unacceptable. "At this time of life, the testis is connected in a very particular manner with the parietes of the abdomen, at that place where, in adult bodies, the spermatic vessels pass out, and likewise with the scrotum. This connection is by means of a substance which runs down from the lower end of

[n] J. Hunter, *A description of the situation of the testis in the fœtus, with its descent into the scrotum*, in his *Observations on certain Parts of the Animal Economy*, p. 13.

[o] Bichat, *Anatomie descriptive*, t. ii. p. 234.

the testis to the scrotum, and which at present I shall call the ligament or gubernaculum testis, because it connects the testis with the scrotum, and seems to direct its course through the rings of the abdominal muscles. It is of a pyramidal form; its large bulbous head is upwards, and fixed to the lower end of the testis and epididymis, and its lower and slender extremity is lost in the cellular membrane of the scrotum. The upper part of this ligament is within the abdomen, before the psoas, reaching from the testis to the groin, or to where the testicle is to pass out of the abdomen; whence the ligament runs down into the scrotum, precisely in the same manner as the spermatic vessels pass down in adult bodies, and is there lost. That part of the ligamentum testis, which is within the abdomen, is covered by the peritonæum all round, except at its posterior part, which is contiguous to the psoas, and connected with it by the reflected peritonæum and by the cellular membrane. It is hard to say what is the structure or composition of this ligament: it is certainly vascular and fibrous, and the fibres run in the direction of the ligament itself, which is covered by the fibres of the cremaster or musculus testis, placed immediately behind the peritonæum. This circumstance is not easily ascertained in the human subject; but is very evident in others, more especially in those whose testicles remain in the cavity of the abdomen after the animal is full grown." [p]

(D) We know that the skin of every part relaxes by heat and contracts by cold, although it be not muscular: in the cold fit of an ague, it is constricted throughout so forcibly as to have acquired, during this state, the appellation of *Cutis Anserina.* The scrotum, being much more lax than any other portion of the skin, experiences these effects to the greatest extent. What is termed dartos is merely thick cellular membrane.

(E) A coat, exterior to the rest, is described by M. Roux, and termed *Envelope fibreuse*. It is an elongated sac, large below to contain the testis and epididymis, and narrow above, affording a sheath to the chord. It vanishes among the cellular membrane of the ring.[q] M. Roux considers this coat as having been known to Haller, from the following passage in Haller's account of the testicle. " Ita fit ut interiores caveæ duæ sunt; superior vasculis

[p] l. c. p. 6.

[q] Bichat's *Anat. Descrip.* t. v. p. 176.

spermaticis circumjecta; inferior testi propria." But Haller continues thus: "Ita sæpe se habet, ut etiam aquæ vis aut in partem testi propriam solam, intacta parte vasculosi funiculi, aut in istam solam, intacta testis vagina, effundatur, neque flatus impulsus de ea vaginali ad istam commeet." [r] He appears therefore to describe merely the tunicæ vaginales of the chord and testis.

(F) The cremaster deserves a little attention. This muscle arises from the superior anterior spinous process of the ileum, from the transversalis abdominis, the internal surface of the Fallopian ligament and neighbouring parts, and, passing through the ring, spreads upon the chord, vanishing upon the beginning of the testicle. Its office is evidently to support the testicle, and to draw it upwards against the groin during procreation. In those animals whose testes, instead of hanging in the scrotum, lie in the perinæum, in the groin, or in the abdomen, this muscle is, as might be expected, much less considerable.

It may here be mentioned that the human testes do not always descend into the scrotum, but occasionally remain, one or both, in the groin or abdomen. Individuals so circumstanced were called κρυψόρχιδες or testicondi, by the ancients. A ridgil is a bull in which one only has descended. In these instances the generative powers are not impaired; — a testicle which has not descended is prevented by the pressure of the neighbouring parts from fully evolving itself, but such persons, it is certain, "*militant non sine gloria.*"

The generative powers indeed are not impaired by the removal of one testis: the Hottentots have been said frequently to deprive their sons of one on arriving at eight years of age, [s] from the belief that monorchs are swift runners. We read in Varro, that, if a bull is admitted to a cow immediately after both testes are removed, impregnation takes place, — "Exemptis testiculis, si statim admiseris, concipere (vaccas)." [t] This at least is certain, that some men have perfectly performed the act of copulation, though unfruitfully, after castration. [u] Many such accounts are suspicious, but in a case mentioned by Sir Astley Cooper in his

[r] *Elementa Physiologiæ*, t. vii. p. 420.

[s] Wilh. ten Rhyne, *De promontor. Cap. bon. spei.* 22. pag. m. 64, and others quoted by Schurig, *Spermatologia*, p. 60. Sparmann informs us that this custom no longer prevails.

[t] *De Re Rustica*. ii. 5.

[u] See examples collected by Schurig, *Spermatologia*, p. 395.

surgical lectures as perfectly unquestionable, the complete power of coition positively remained some time after the removal of both organs by that surgeon, and gradually diminished.

The notion that each testicle, or each ovarium, is destined for the procreation of but one sex, is too nonsensical.

(G) Lewis Hamme, a young German, discovered the seminal animalcules, and shewed them to Leeuwenhoeck; and the sagacious Dutchman, catching eagerly at the discovery, published an account of them illustrated by plates. Hartzoeker, ambitious of the honour of the discovery, wrote upon the subject the following year, and asserted that he had seen the animalcules three years before they were observed by Hamme. The subject, being the very summit of filthiness, excited the earnest attention of all Europe. Physiologists, naturalists, Popish priests, painters, opticians, and booksellers, all eagerly joined in the pursuit of the seminal animalcules, and the lascivious Charles the Second of England commanded them to be presented to him swimming and frisking in their native fluid. Some of the curious could not find them. Others not only found them, but ascertained their length was $\frac{3}{1000000}$ of an inch, their bulk such as to admit the existence of 216,000 in a sphere whose diameter was the breadth of a hair, and their rate of travelling nine inches in an hour. They saw them too in the semen of all animals, and, what is remarkable, of nearly the same size and shape in the semen of the largest and of the smallest,—in the semen of the sprat and of the whale; they could distinguish the male from the female; in the semen of a ram they beheld them moving forwards in a troop with great gravity like a flock of sheep; and in the human semen, Dalenpatius actually saw one indignantly burst its wormy skin and issue forth a perfectly formed human being. The little creatures would swim in shoals towards a given point, turn back, separate, meet again, move on singly, jump out, and dive again, spin round, and perform various other feats, proving themselves, if not the most delicate, at least the drollest, beings that ever engaged the attention of philosophers. Their strength of constitution being an important object of enquiry, they gave proofs of their vigour not only by surviving their rough passage through the urethra, three, four, and seven days, but by impregnating a female at the end of this time, and, on being removed from her, by impregnating even a second.

Surely never was so much folly and bestiality before committed under the name of philosophy.

Abr. Kauw, Boerhaave, Maupertuis, Lieutaud, Ledermuller, Monro Secundus, Nicolas, Haller, and, indeed, nearly all the philosophers of Europe, were satisfied of the existence of the animalcules. Buffon and his followers, prejudiced in favour of an hypothesis, although they did not deny that the semen contained innumerable rapidly moving particles, contended that these were not animalcules, but organic particles, and Linnæus imagined them to be inert molecules thrown into agitation by the warmth of the fluid. Their reality, however, might be regarded as established. But, finally, to determine the question, and accurately to ascertain every circumstance relating to them, the celebrated Spallanzani began a long course of observations and experiments about the middle of the last century, unbiassed in favour of any opinion, and endeavouring to forget entirely all that had been written upon the subject. The human semen the worthy Abbé assures us that he procured from dead bodies immediately after dissolution; but that of brutes was obtained either after death or during life.

He found in the former innumerable animalcules with an oval body and a tail, or appendix, tapering to a point. This appendix, by moving from side to side, propelled them forwards. They were in constant motion in every direction. In about twenty-three minutes their movements became more languid, and in two or three hours they generally died, sinking to the bottom of the fluid, with their appendices extended. The duration of their life, however, depended much upon the temperature of the weather; at $-2°$ (Reaumur) they died in three-quarters of an hour; while at $7°$ they lived two hours; and at $12\frac{1}{2}°$, three hours and three-quarters. If the cold was not too intense, they recovered upon the temperature being raised; when only $-3°$ or $-4°$ they recovered after a lethargy of fourteen hours and upwards; and, according to the less intensity of the cold, they might be made to pass from the torpid to the active state more frequently. They were destroyed by river, ice, snow, and rain-water; by sulphur, tobacco, camphor, and electricity. Even the air was injurious to them; — in close vessels their life was prolonged to some days, and their movements were not constant and hurried. They were of various sizes and perfectly distinct from all species of animalcules found in vegetable infusions, &c.

The seminal animalcules of different kinds of animals had generally each some peculiarity. In short, Spallanzani completely confirmed the principal observations of Leeuwenhoeck, and satisfactorily explained the sources of the inaccuracies of other enquirers.[x]

Although these beings are most numerous in the semen, he detected them occasionally in other fluids; — in the mesenteric blood of female frogs and salamanders, and in the blood of a tadpole and a calf.[y]

According to Vauquelin's analysis of the semen, 100 parts contain,

Of Water	90
Mucilage	6
Phosphate of lime	3
Soda	1

In some days it putrefies and becomes covered with the byssus septica.[z]

(H) Mr. Hunter's arguments are the following: — 1. "The semen, first discharged from the living body, is of a blueish white colour, in consistence like cream, and similar to what is found in the vasa deferentia after death; while that which follows is somewhat like the common mucus of the nose, but less viscid. The semen becomes more fluid upon exposure to the air, particularly that first thrown out; which is the very reverse of what happens to secretions in general. The smell of the semen is mawkish and unpleasant, exactly resembling that of the farina of a Spanish chesnut: and to the taste, though at first insipid, it has so much pungency, as, after some little time, to

[x] *Opuscoli di Fisica animale e vegetabile*, vol. ii. Prevost and Dumas have lately confirmed the observations of Spallanzani as to the semen of various animals. But for obvious reasons, they say, they determined from the first not to search for the animalcules in man, and recommend this examination to the anatomists of Paris, where there are so many executions. *Annales des Sciences Naturelles*, t. i. and ii.

[y] Creatures of an inch to an inch and a quarter in length, and of the same general shape as the seminal animalcules, inhabit the mesenteric arteries of asses, horses, &c. Mr. Hodgson found them in seven asses out of nine. (*A Treatise on the the Diseases of Arteries and Veins*, &c.) To increase the wonder, the intestines of the human *embryo* have been found containing worms. Goeze, *Versuch einer naturgeschichte der Eingeweidwürmer*.

[z] *Annales de Chimie*, t. x.

stimulate and excite a degree of heat in the mouth. But the fluid contained in these vesiculæ in a dead body, is of a brownish colour, and often varies in consistence in different parts of the bag, as if not well mixed. Its smell does not resemble that of the semen, neither does it become more fluid by being exposed to the air." On opening two men immediately after death, the contents of the vesiculæ were of a lighter colour than he usually found them in persons who had been some time dead, and in one of the instances so fluid as to run out upon cutting the vesiculæ, but they were similar to the semen neither in colour nor smell. An examination of the vesiculæ of the horse, boar, rat, beaver, and guinea-pig, afforded the same results. In the last animal, the contents near the fundus of the vesiculæ were viscid, and gradually firmer, till, near the opening into the urethra, they were as solid as common cheese, and no such substance could be detected in the vagina of the female after her union with the male. 2. During lasciviousness, the testicles swell, and they become painful if the semen is not discharged; in coition, it may be added, they are drawn forcibly by the cremaster against the pubes, as if to assist the discharge of their contents at the period of emission. 3. In the old and debilitated, the vesiculæ are as full as in the young and vigorous. 4. Nay, in four men who had each lost a testicle, the vesicula on one side was equally full as on the other, although the men had survived the operation a considerable length of time. The same was discovered in two cases, where, by mal-formation, one testicle had no communication with the corresponding vesicle. In the gelding and the stallion their contents are similar and nearly equal in quantity. The vas deferens has no communication in some animals with the vesiculæ, and in others, as the horse, where a communication does exist, the common duct is not of sufficient length to permit the regurgitation of the semen into the vesiculæ. 4. Some animals, especially among the carnivora, have no vesiculæ seminales, yet in their copulation they differ not from those which have. M. Richerand indeed asserts, that animals destitute of these organs are longer in coition than others, from having no reservoir for an accumulation of semen.[a] But he is mistaken. For on inspecting Cuvier's account of animals without and with

[a] *Elémens de Physiologie*, c. x.

vesiculæ, no connection whatever appears between their presence or absence and the length of copulation,

In opposition to these arguments it is urged, that a fluid, gently propelled along the human vas deferens, does not pass into the urethra, but regurgitates into the vesicula.[b] But, granting this true, we have no proof that the secretion of the testes leaves the vasa deferentia except during emission, when this regurgitation is impossible. It may also be contended that, in many men, the act of straining at the water-closet often instantly discharges from the urethra, without the least sensation, a large quantity of a fluid, which is exactly similar, in colour, consistence, and odour, to that of a nocturnal emission. The compression cannot squeeze this fluid from the testes. If a partisan of Mr. Hunter should say that the *extremities* of the vasa deferentia afford it, we may reply to him that Mr. Hunter found them full of the same kind of fluid as the vesiculæ. I believe, however, that we are unacquainted with the pure secretion of the testes, and that far the greatest portion of an emission is secreted by the vesiculæ seminales and prostate gland; and that therefore some persons may, by forcing down, occasion a discharge apparently identical with an emission, though not containing a particle of matter furnished by the testes. The fact, already mentioned, of emission occurring for a long period after the removal of both testes, — till the removal had much deranged the whole genital system, forcibly corroborates this idea. The difference discovered by Mr. Hunter between the fluid found in the human vesiculæ seminales after death and that of an emission, is nothing more than might be expected if we were certain that they were the same,[c] and as the matter squeezed out by some in straining exactly resembles that of a regular emission, this fact alone would be fatal to Mr. Hunter's opinion, in regard to man, unless we relinquish the notion of the fluid of human emission being chiefly true semen from the testes.

In different species of brutes the fluid of emission may be furnished in different proportions from the testes, vesiculæ, and prostate, and the effects of pressure and seminal debility in them are unknown. Additional vesiculæ seminales are sometimes seen open-

[b] Winslow, Ruysch, Duverney and others, quoted by Haller.

[c] In the two men opened by J. Hunter soon after death, the vesicular fluid was actually much less brown than usual.

ing separately. Cuvier says, that the muscular part of the urethra in brutes is full of semen at rutting time, so that it may pass into the additional vesiculæ.

(I) Accumulation of blood it is supposed may be produced in three ways. 1. By a mechanical impediment to its return: but there is no reason whatever to ascribe ordinary erection to compression. 2. By an increased flow of blood to a part, so that the vessels receive it faster than they convey it away. Here the vessels of the part itself in which the accumulation exists, are said by some to act more violently than usual; by others, the neighbouring larger vessels which supply these: their frequency of action, however, is not increased, but always remains correspondent with that of the heart. Were the vessels of the part itself to act more violently than usual, that is to say, to contract to a smaller and relax to a greater dimension than usual, (though an ordinary alternate contraction and relaxation are hypothetical) more blood would indeed subsist in them during their relaxation, but less than usual would subsist in them during their contraction, and there could be no accumulation, no inflammation. If the neighbouring large vessels act more violently than usual, (though their ordinary alternate contraction and relaxation are also hypothetical) they may be conceived to produce an accumulation of blood and a distention of the smaller vessels. 3. If the vessels of any part become dilated and do not contract in proportion, this circumstance will be sufficient to produce an accumulation, without any necessity for supposing an increased action of the neighbouring larger vessels. This explains inflammation: and in Bichat's *Anatomie Descriptive*, this explanation is given of erection. The corpora cavernosa (which always contain florid blood,) spontaneously dilate, and accumulation ensues. For this purpose it is not necessary that they should be muscular, but Mr. Hunter asserts their muscularity: in a horse he found them muscular to the eye, and they contracted upon being stimulated.

The heart, however, as in all cases of what is called increased determination of blood, lends its powerful aid by acting with augmented force.

As to the final cause of erection, the organ, by acquiring increased bulk, firmness, and sensibility, becomes adapted for affording and experiencing to the utmost extent the effects of friction both as exciting pleasure and as stimulating the secreting vessels; the increased length and narrowness of the urethra render the emission more forcible.[e]

(K) If Gall is right in placing the seat of sexual desire in the head, this kind of erection may be explained by supposing the irritation, arising in the cerebellum from the great accumulation of its blood, to produce a correspondent irritation in the organs of generation: thus the epileptic paroxysm is not unfrequently accompanied by an emission. Nocturnal emissions occur most frequently after a person has been long in bed and supine, — the cerebellum the lower part of the encephalon, if the occiput is, as usually, raised by a pillow. That may, however, be explained by the urine accumulating in the bladder during the continuance of repose, and stimulating the generative parts connected with this receptacle the more readily in the supine posture; and this view is countenanced by the large quantity of urine generally made on waking after nature has been thus relieving the chaste unmarried man.

(L) The discharge of semen resembles the discharge of the fluids of other glands. It is excited by the abundance of the fluid, by mental or local stimulus, but most by mechanical irritation of the extremity of the excretory duct, for in such a point of view must be regarded the friction of the glans penis in copulation. The fluid is accumulated in the bulb of the urethra, since it must be accumulated somewhere to be emitted so copiously, and no other use can be assigned to the bulb; and if the vesiculæ do not receive it, no other part than the bulb can; besides, it is upon the bulb that the muscular contraction of the venereal paroxysm first acts. "The semen acting as a stimulus to the cavity of the bulb of the urethra, the muscles of that part of the canal are thrown into action, the fibres nearest the bladder probably act first, and those more forward in quick succession, and the semen is projected with some force. The blood in the bulb of the urethra is by the same action squeezed forward, but requiring a greater impulse to propel it, is rather later than the semen, on which it presses from behind;

[e] Mr. Shaw pointed out a venous network running along the inside of the urethra, but accumulated at what is called the membranous part, connected with the corpus spongiosum, and forming two columns with a groove in the middle. This must principally assist in narrowing the canal during erection, and, as the columns unite before the prostate, must also contribute to prevent the semen from moving towards the bladder, or the urine from flowing from the bladder. *Med. Chir. Trans.* vol. x.

the corpus spongiosum being full of blood, acts almost as quick as undulation, in which it is assisted by the corresponding constriction of the urethra, and the semen is hurried along with a considerable velocity." [f]

(M) Zeno's practice was conformable to his principles. He is recorded to have embraced his wife but once in his life, and then out of mere politeness.

Zenobia, the celebrated Queen of Palmyra and the East, was as extraordinary a wife. She never admitted her husband's embraces but for the sake of posterity, and, if her wishes were baffled, she reiterated the experiment in the ensuing month.[g]

Epicurus, Democritus, &c. were nearly of the same opinion with Zeno, and the Athletæ, that their strength might be unimpaired, never married. The Rabbies, in their anxiety to preserve their nation, are said to have ordered, with the view of preventing the loss of vigour, that a peasant should indulge but once a week, a merchant but once a month, a sailor but twice a year, and a studious man but once in two years. Moses forbad indulgence before battle. Many plants die as soon as they have flowered: stags and fish are emaciated after the sexual season, and the latter are no longer fit to eat: while the prevention of fructification by the removal of the sexual organs renders annual plants biennial and the latter triennial.

[f] Hunter, *Observations on the glands situated between the rectum and bladder, called vesiculæ seminales*, l.c. 45.

[g] *Augustan History*, quoted by Gibbon, *Decline and Fall, &c.* vol. ii. p.33.

SECT. XXXVII.

OF THE GENITAL FUNCTION OF WOMAN IN GENERAL.

539. As the male organs are fitted for giving, so the female organs are fitted for receiving, and are correspondently opposite to the former. In some parts, the organs of both sexes are very analogous to each other in structure. Thus the *clitoris*, lying under the pubes in the superior commissure of the labia, agrees in many respects with the penis of the male, although distinct from the urethra and therefore imperforate, and extremely small in well-formed women. It is recorded to have been, in some adult females, of as comparatively large size as we stated it usually to be in the fœtus, (492) and these instances have probably given rise to most of the idle stories of hermaphrodites. [a] Like the penis, it has its corpora cavernosa, is capable of erection, is covered with a prepuce, and secretes a smegma not dissimilar from the Littrian. (525) [b]

540. From the clitoris the *nymphæ* descend, also occasionally of great size, [c] which has been the source of other idle

[a] Vide Haller, *Comment. Soc. Scient. Gotting.* vol.i. p.12. sqq.

And among the moderns, D. Clarke in Sir Everard Home, *Phil. Trans.* 1799. p. 163.

[b] In warm climates it too is liable to accumulation and acrimony, and has hence been the occasion of the custom of female circumcision in many hot parts of Africa and Asia. Carst. Niebuhr has given a view, executed to the life, of the genitals of a circumcised Arabian female, eighteen years of age, whom he himself was singularly fortunate in examining during his oriental tour. *Beschreib. von Arabien*, p. 77. sq.

And Osiander, *Denkwürdigkeiten für die Heilkunde*, &c. vol.ii. tab.vi. fig.1. (A)

[c] Their number likewise has occasionally varied. Vide Neubauer, *De triplici nympharum ordine.* Jenæ. 1774. 4to.

tales, [d] and, like the clitoris, possessing a high degree of sensibility. They appear in some measure to direct the stream of urine, because the *opening of the urethra*, which is very short in females, lies under their commencement; and it is frequently ciliated, as it were, with small papillary folds. [e]

541. Under the termination of the urethra lies the *opening of the vagina*, surrounded by various kinds of cryptæ, *v. c.* the lacunæ uretheric æ of De Graaf, [f] and the orifices of the prostates, as they are improperly termed, of Casp. Bartholin, [g] which secrete an unctuous mucus. [h]

542. Across the opening of the vagina, the *Hymen* [i] is extended, — a membrane generally circular, and found, as far as I know, in the human subject only, of this form and in this situation. [k]

The remains of the lacerated hymen become the *carunculæ myrtiformes*, which are of no regular number, and are infallible signs of the loss of virginity. (C)

543. The *vagina*, ascending between the urinary bladder

[d] I allude to the singular ventral skin of the Hottentot women. Wilh. ten. Rhyne, from personal inspection long ago, considered it as enormous pendulous nymphæ. *De promontorio b. spei.* p.33.

I have treated this point at large in my work, *De Gen. Hum. Var. Nat.* 242. ed. 3. (B)

Steller relates something similar in regard to the Kamtschatkan women. *Beschreib. v. d. Lande Kamtschatka*, p.300.

[e] I find the opening of the urethra surrounded by very beautiful cutaneous cilia of this kind, in a remarkable specimen of the genitals of a woman upwards of eighty years of age. The hymen is entire, and all the other parts most perfectly, and, as it were, elaborately, formed. They are preserved in my museum, and my friend and colleague, Osiander, has represented them in a plate. l. c. tab. v.

[f] See J. James Huber's plates of the uterus, among those of Haller. fasc. 1. tab. ii. fig. 1. *g.*

[g] Ibid. fig. 1. *b. b.* — fig. 5. *d.*

[h] Such also are the two foramina, very frequently observed in living women by J. Dryander. at the extremity of the vagina. Nic. Massa, *Epist. Medicinal*, t. i. page 123. b.

[i] John Wm. Tolberg, *De Varietate Hymenum.* Hal. 1791. 4to.

Osiander, l.c. tab. i.—vii.

[k] *Handbuch der vergleich, Anat.* p.472. respecting parts somewhat analogous in some brute females, see the distinguished Duverney, *Mém. présentées*, &c. physical class, t. ii. p.89.

and rectum, consists of a very vascular cellular parenchyma, is surrounded inferiorly by the *constrictor cunni*,[l] and lined internally with a very soft coat, which is marked by two beautiful *columns of rugæ*,[m] — an anterior and posterior,[n] pouring forth a mucus into its cavity.

544. Upon the superior part of the vagina rests the *uterus*, suspended on either side by its broad ligaments.

Its cylindrical cervix[o] is embraced by the vagina, and perforated by a narrow canal, which, like the vagina, is marked by rugæ denominated the arbor vitæ, and is generally lined with a viscid mucus at each opening, but particularly at the superior or internal.

545. The substance of the uterus is peculiar, — a very dense and compact parenchyma[p] abounding in blood-vessels, which run in a curious serpentine direction,[q] and the veins are destitute of valves. It has also on its external surface a supply of lymphatics,[r] and of nerves,[s] which occasion its remarkable sympathy with other parts.

546. The uterus is covered externally with peritonæum; its internal cavity is small, and lined, especially at the fundus, with a soft and very delicate spongy membrane, which is composed, according to some, (92) of colourless arteries and veins, (92) and,[t] according to others, of lymphatics.[u]

547. With respect to its muscularity, asserted by some,[x]

[l] Eustachius, tab. xiv. fig. i. XX.
Santorini, *Tab. Posth.* xvii. 1. 1.

[m] Huber, *De Vaginæ Uteri structura rugosa, necnon de Hymene.* Gotting. 1742. 4to.

[n] Vide Haller, *Icones Anat.* fasc. ii. tab. vi. fig. 1. 2.

[o] Roederer, *Icones Uteri Humani,* tab. vii. fig. 2. 3. 4.

[p] J. Gottfr. Weisse (Præs. Rud. Boehmer) *De Structura Uteri non musculosa, sed celluloso vasculosa.* Vitemb. 1784. 4to.
I. G. Walter, *Was ist Geburtshülfe.* Berlin, 1808, 8vo. p. 54.

[q] Id. *De Morbis Peritonæi,* tab. i. ii.

[r] Mascagni, tab. xiv.

[s] Walter, *Tab. Nerv. Thorac. et Abdom.* tab. 1.
J. F. Osiander, *Commentatio præmio Regio ornata, qua edisseritur uterum nervos habere.* Gott. 1808. 4to.

[t] Ferrein, *Mémoires de l'Acad. des Sc. de Paris,* 1741. p. 375.

[u] Mascagni, l. c. page 4.

[x] See, for instance, Sue, *Mém. présentés,* vol. v.
L. Calza, *Atti dell' Acad. di Padova,* t. i. ii.

and denied by others,[y] I may remark that I have never yet discovered a true muscular fibre in any human uterus which I have dissected, whether impregnated or unimpregnated, recent or prepared; but it must be allowed by those who maintain the muscularity of the uterus, that the fibres, which they call muscular, have qualities very different from those of all others in the system, especially since they themselves entertain doubts of the existence of nerves in the substance of the uterus, without which, one cannot imagine a true muscle. (302) I am daily more convinced that the uterus has no true irratibility, (301) but, if any part of the body has, a vita propria, (42) perfectly correspondent with the peculiar motions and functions of the uterus, which are not referable to any properties common to the similar parts, (39-41) and which appeared to the ancient physicians and philosophers so peculiar, that the uterus was by them denominated an animal within an animal.[z] (D)

548. From the angles of the roof or fundus of the uterus arise on each side the *Fallopian tubes*[a] — narrow and tortuous canals, running in the upper part of the duplicature of the broad ligaments, similar in texture to the vagina, except that they are internally destitute of rugæ, and lined by a very soft and delicate spongy substance.

549. The extremity which opens into the abdomen is not only larger than that which opens into the uterus, but is surrounded by laciniated and, as it were, digitated *fimbriæ*, peculiar and elegant in structure, that are probably of great importance in conception, since they appear to become turgid, as well as the tubes themselves, during the venereal œstrum, and to embrace the ovaria over which they lie.

[y] Consult, besides the great Malpighi, Walter, *Betracht. über die Geburstheile des weiblichen Geschl.* p. 25. sq.

Chr. H. Ribke, *über die Structur der Gebährmutter.* Berl. 1793. 8vo.

But chiefly J. F. Lobstein, *Magasin Encyclopédique, redigé par* Millin, vol. xlix. 1803, t. i. page 357. sq.

[z] I have spoken of these points at large in my program, *De vi vitali sanguini deneganda,* &c. Gott. 1795. 4to. p. 15. sq.

[a] Fallopius, *Observ. Anat.* p. 197.

550. The *ovaria*, or, as they were termed previously to the time of Stenonis,[b] the female testes, are composed of a tough and almost tendinous covering, and a dense and closely compacted cellular substance, which contains in each ovarium about fifteen ovula, called Graafian, viz. vesicles, or rather drops of albuminous yellowish serum, which coagulates like fine white of egg, if the recent ovarium is plunged into boiling water.

551. Such an albuminous drop appears to be the chief fluid that the female contributes in the business of conception, and it is probable, that, during the adult state, these drops become mature in succession, so that they one by one force their way and finally burst the covering of the ovarium and are received by the abdominal extremity of the Fallopian tube.

552. Besides the albuminous drop which escapes from the ovarium, another fluid, improperly styled *female semen* by the ancients, is poured forth during the venereal œstrum. Its nature, source, and quantity, are envelopĕd in no less mystery than its office.[c]

NOTES.

(A) This custom is mentioned even by Strabo. (p. 284.) Burckhardt states, that " the daughters of the Arabs, Ababde and Djaafere, who are of Arabian origin, and inhabit the western bank of the Nile, from Thebes, as high as the cataracts, and generally those of all the people to the south of Kenne and Esne, as far as Sennaar, undergo circumcision, or rather excision of the

[b] For Stenonis was the first who asserted that the testes of women were analogous to an ovarium, in 1667. See his *Elementor. Myologiæ Specimen.* page 117. sqq.

[c] Respecting this still problematical fluid see Carpus in Mundinum. P. cxcviii. sqq. and cccviii.

Harvey, *De Generatione Animal.* p. 95.

De Graaf, *De Mulierum Organis*, p. 194.

clitoris, at the age of from three to six years." The healing of the wound is contrived to close the genitals, excepting at one point for the passage of the urine, and as the adhesions are not broken through till the day before marriage, and then in the presence and with the assistance of the intended bridegroom himself, no doubts of the fair's virginity can harass his breast.[d]

The same traveller, as well as Browne and Frank, relates that many slave girls have their genitals sewn up, and, like eunuchs, become more valuable on account of their unfitness for sexual connection. "Mihi contigit," says he, "nigram quandam puellam, quæ hanc operationem subierat, inspicere. Labia pudendi acu et filo consuta mihi plane detecta fuere, foramine angusto in meatum urinæ relicto." He adds, "Apud Esne, Siout, et Cairo, tonsores sunt, qui obstructionem novacula amovent, sed vulnus haud raro lethale evenit."

(B) Blumenbach states it to be a prolongation of the labia on the authority of Le Vaillant, but we are now certain that W. ten. Rhyne was correct, and that it is a prolongation of the nymphæ,[e] which often hang five inches below the labia. The

[d] *Travels in Nubia*, p. 332. sqq. The adhesion may prevent admission of the male organ, but, like a dense hymen, does not always prevent impregnation. In the *Med. Chir. Trans.* vol. xi., a female of the Eboe nation is mentioned as having been at an advanced state of pregnancy, in Jamaica, notwithstanding that, in consequence of this operation, performed upon her when a child, in her native land, "a cicatrix extended from the mons veneris to within an inch of the anus, where there existed a small orifice barely sufficient for the introduction of a small female catheter, through which orifice the urine and menses exuded. The adhesion being removed by an incision with a sharp-pointed bistoury, the delivery was easily accomplished." A case is just mentioned by professor Rossi (*Archives générales*, Oct. 1827), of impregnation with no other canal than one, just sufficient to admit a small sound, opening within the anus. Examples of the necessity for cutting or tearing the hymen, at the time of labour, may be found in Ruysch, Mauriceau, and F. Hildanus, &c. and in the *Transact. of the London Medical Society*, vol. i. P. 2. When the hymen is imperforate, impregnation obviously never occurs, and an incision is required for the escape of the accumulated menstrual fluid. See *v. c.* Ambrose Paré, lib. xxiii. c. xlii. or the *Med. Records and Researches*. Harvey mentions a beautiful white mare belonging to the queen, in which the entrance of the vagina had been fastened up by iron rings to prevent her being covered, but, to the surprise of every body, she was one day found to have foaled, and her offspring, in coming forth, had lacerated the vagina on one side of the rings, which still retained their situation. *De Partu Exercit.* p. 557. *Opera.*

[e] Dr. Somerville, *Med. Chir. Trans.* vol. vii. 1816. Barrow, *Travels into the interior of Southern Africa*, vol. i.

same tribe of Hottentot women have another connate singularity in the same quarter, common also to a variety of their sheep, and the source of all the charms of the Hottentot Venus — a brilliant example of denomination on the principle of *lucus a non lucendo.* Her immense and tremulous buttocks displayed on dissection an enormous accumulation of fat between the skin and muscles.[f]

(C) Cuvier declares he has found the hymen in very many mammalia,[g] overthrowing the doctrine, so strenuously maintained by Haller, of its existence for moral purposes. And, were it confined to the human female, the various size of its aperture and the various firmness of the organs, must ever leave those in uncertainty who can on their marriage indulge in sensual doubts. We read in Hume that Henry the Eighth, who certainly had his share of experience, boasted his discrimination;[h] but in the east the difficulty was in ancient times proverbial.[i] The lover of Italian literature knows how exquisitely natural is every description of Boccacio's, and will recollect his story of the daughter of the Sultan of Babylon: — "Essa, che con otto uomini forse diecemilia volte giaciuta era, allato a lui (al Re del Garbo) si coricò per pulcella, e fecegliele credere, che così fosse: e Reina con lui lietamente poi più tempo visse: e perciò si disse: Bocca basciata non perde ventura, anzi rinnuova, come fa la luna."[k]

(D) The muscularity of the uterus is allowed by Malpighi, Morgagni, Mery, Littre, Astruc, Ruysch, Monro, Vieussens, Haller, &c.

Mr. C. Bell gives the following description of the muscular structure of this organ.

"The muscularity of the uterus is proved by direct ocular demonstation of the fibres in dissection, by the thickness of the fibres corresponding with their degree of contraction, by the visible action of the human uterus during life, by the resemblance of the laws of its contraction, (as felt and as perceived in its consequences) to those which govern the contraction of other hollow viscera, and lastly, by the vermicular and intestinal motions of the uterus, as seen in experiments upon brutes."

[f] Cuvier, *Mémoires du Museum*, t. iii. p. 269.
[g] *Leç. d'Anat. comp.* t. v. p. 131-2.
[h] *History of England*, ch. xxxii.
[i] *Proverbs*, xxx. 19.
[k] *Decamerone.* Giornata seconda. Novella vii.

" The most curious and obviously useful part of the muscular substance of the uterus has been overlooked; I mean the muscular layer of fibres which covers the upper segment of the gravid uterus. The fibres arise from the round ligaments, and regularly diverging, spread over the fundus until they unite and form the outermost stratum of the muscular substance of the uterus."

" The substance of the gravid uterus is powerfully and distinctly muscular; but the course of the fibres is here less easily described than might be imagined. Towards the fundus the circular fibres prevail; towards the orifice the longitudinal fibres are most apparent; and, on the whole, the most general course of the fibres is from the fundus towards the orifice. This prevalence of longitudinal fibres is undoubtedly a provision for diminishing the length of the uterus, and for drawing the fundus towards the orifice. At the same time these longitudinal fibres must dilate the orifice, and draw the lower part of the womb over the head of the child.

" In making sections of the uterus while it retained its natural muscular contraction, I have been much struck in observing how entirely the blood-vessels were closed and invisible, and how open and distinct the mouths of the cut blood-vessels became when the same portions of the substance of the uterus were distended and relaxed." " A very principal effect of the muscular action of the womb is the constringing of the numerous vessels which supply the placenta, and which must be ruptured when the placenta is separated from the womb."

" Upon inverting the uterus and brushing off the decidua, the muscular structure is very distinctly seen. The inner surface of the fundus consists of two sets of fibres, running in concentric circles round the orifices of the Fallopian tubes. These circles at their circumference unite and mingle, making an intricate tissue. Ruysch, I am inclined to believe, saw the circular fibres of one side only,[1] and not adverting to the circumstance of the Fallopian tube opening in the centre of these fibres, which would have proved their lateral position, he described the muscle as seated in the centre of the fundus uteri. This structure of the inner surface of the fundus of the uterus is still adapted to the explanation of Ruysch, which was, that this produced contraction

[1] Discovered by Weitbrecht, and first accurately observed by Dr. Hunter.

and corrugation of the surface of the uterus, which the placenta not partaking of, the cohesion of the surface was necessarily broken.

" Further, I have observed a set of fibres of the inner surface of the uterus which are not described. They commence at the centre of the last described muscle, and having a course at first in some degree vorticose, they descend in a broad irregular band towards the orifice of the uterus. These fibres co-operating with the external muscle of the uterus, and with the general mass of fibres in the substance of it, must tend to draw down the fundus and lower segment of the uterus over the child's head.

" I have not succeeded in discovering circular fibres in the os tincæ corresponding in place and office with the sphincter of other hollow viscera, and I am therefore inclined to believe, that, in the relaxing and opening of the orifice of the uterus, the change does not result from a relaxation of muscular fibres surrounding the orifice. Indeed, it is not reasonable to conceive that the contents of the uterus are to be retained during the nine months of gestation by the action of a sphincter muscle. The loosening of the orifice, and that softening and relaxation which precede labour, are quite unlike the yielding of a muscular ring."[m]

[m] *Med. Chir. Trans.* c. iv.

SECT. XXXVIII.

OF THE MENSTRUA.

553. An important, and indeed the most frequent, function of the uterus, is to afford a menstrual fluid during about thirty years,[a] — a law imposed upon no other species of animal:[b] — Woman, in the words of Pliny, is the only menstruating animal. The females of no nation, hitherto explored, are exempt from this law,[c] since it is among the requisites in the female sex for the propagation of the species.

554. The commencement of this function usually occurs about the fifteenth year, preceded by symptoms of plethora, by a sense of heaviness in the chest, and of tension in the loins, by lassitude of the limbs, &c. At first a reddish fluid

[a] Consult, besides many others, F. C. Nägele, *Erfahrungen über Krankh. des weibl. Geschlechts.* Manheim. 1812. 8vo. p. 265.

[b] Most writers upon Natural History, and among the rest Buffon, allow the existence of a periodical discharge of this kind in some other animals, especially in certan simiæ. But after carefully observing the females of the species of simiæ mentioned by him, (*v. c.* of the simia *sylvanus*, and *cynomolgus*, the papio *maimon*, &c.) for a number of years, I easily discovered that these supposed catamenia in some did not occur at all, and, in others of the very same species, were merely a vague and sparing uterine hemorrhage, *observing no regular period.*

[c] There is hardly occasion at present to refute the unfounded assertion, that in some countries, particularly on the continent of America, the women do not menstruate. This opinion appears to have originated from the circumstance of the Europeans, who visited those countries, and saw innumerable women nearly naked, never observing any menstrual stains upon them. For this there might be two reasons. First, the American women are, by a happy prejudice, regarded as infectious while menstruating, and retire from society into solitary huts, to the benefit of their health. Secondly, their extreme cleanliness, and the modest position in which they place their limbs, would prevent any vestige of the catamenia from being observable, as Adr. Van Berkel expressly states, *Reisen nach Rio de Berbice und Surinam,* p. 46.

generally flows from the genitals, becoming by degrees of a more bloody colour, and at length completely so. This has a peculiar odour, coagulates but imperfectly, and differs also in other respects from blood. It continues to flow slowly for some days, and the unpleasant symptoms above described cease in the mean time.

555. This red discharge returns afterwards about every four weeks, and continues about six days, during which time a healthy woman is supposed to lose, perhaps, from five ounces to half a pound of blood.

556. This action is usually *suspended* during pregnancy or suckling.

It entirely *ceases* after existing about thirty years; and, consequently, in our climate, about the forty-fifth year of age.[d]

557. By some, the vagina, by others, and with more probability, the uterus, is considered the *source* of this discharge. Instances of women menstruating although pregnant, or having the uterus imperforate, or inverted and prolapsed, do not favour the former opinion, but prove only the extraordinary compensating powers of nature, who successfully employs new ways, when the usual one is obstructed. On the other hand, the dissection of many women who have died during menstruation, has discovered the cavity of the uterus bedewed with the catamenia.[e] We say nothing of the a priori argument — that the purpose of menstruation is probably to render the womb fit for pregnancy and for nourishing the fœtus.[f] On the same account, the arteries rather than the veins appear to be the source of the discharge.[g]

558. The investigation of the *causes* of the periodical return

[d] H. Helm. Spitta, *Commentatio præmio Regio ornata, sistens mutationes in organismo et œconomia fœminarum cessante fluxus menstrui periodo.* Gotting. 1818. 4to.

[e] See, for example, Morgagni, *Adv. Anat.* 1. tab. iii. M.M.M.

[f] L. H. Chr. Niemeyer, *De menstruationis fine et usu.* Gott. 1796. 8vo.

[g] J. Fr. Osiander, on the contrary, argues on the side of the veins, *Diss. de fluxu menstruo atque uteri prolapsu.* Gott. 1808. 4to. p. 14.

of this hemorrhage is so difficult, that we can obtain nothing beyond probability, and must not dare to offer any thing merely conjectural.[h]

The proximate cause is supposed to be a *local*[i] plethoric congestion, — an opinion with which the symptoms preceding menstruation, and the abundance and nature of the uterine vessels, agree very well.

Among the remote causes may be enumerated the erect posture peculiar to the human race, the peculiar parenchyma of the uterus, and its vita propria.

It will be better to confess our ignorance of the cause of its periodical return, than to indulge in vain hypotheses: for all the periodical phenomena of health and disease, *that continue more than twenty-four hours*, have hitherto appeared among the mysteries of animal nature.

NOTE.

I have known some women bear children before they had ever menstruated, and others after menstruation had entirely ceased. Many authors relate instances of women being mothers without ever menstruating. Dr. Foderé attended a woman who had menstruated but once, and that in her seventeenth year, although thirty-five years of age, very healthy, and the mother of five

[h] Those who feel interested in this enquiry, may consult, among other writers, Abr. D'Orville, *Disquisitio* (Præs. Haller), *causæ menstrui fluxus.* Gotting. 1748. 4to.

Gisb. Verz. Muilman, *An ex celebrata hactenus opinione de plethora universali vel particulari vera fluxus menstrui causa explicari possit?* LB. 1772. 4to.

Theod. Traug. Jaehkel (Præs. Krause), *Aetiologia fluxus menstrui.* Lips. 1784. 4to.

[i] The *universal* plethoric orgasm, as it was termed, which some formerly regarded as the cause of menstruation, has been long since refuted by more enlightened physiologists. To the arguments of the latter, we may be permitted to add the instance of the celebrated Hungarian sisters formerly mentioned (78. note f.), who, from monstrous formation, were united together. Although the same blood flowed in each on account of the union of the abdominal blood-vessels at the loins, they differed frequently both in the period and the quantity of their menstruation.

children.[k] Morgagni mentions a mother and daughter who both were mothers before menstruation. De la Motte saw cases of this kind.[l] Sir Everard Home mentions a young woman who did not menstruate till after her pregnancy.[m] Dr. Merriman has lately mentioned that he attended a lady who had not menstruated for a year and a half previous to her delivery.[n]

Neither is the pleasure of coition requisite to impregnation; for the mother of one of Napoleon's generals, as well as of other children, told a friend of mine, "Qu'elle n'avoit eu que le douleur d'enfanter," and the late Dr. Heberden has the following passage:—"Duo mariti mihi narrarunt uxores suas in venerem fuisse frigidas, omni ejus cupiditate et voluptate carentes; sæpe tamen gravidas factas esse, et recte peperisse."[o] Gall has known similar cases.[p] There can therefore be no reason why a woman should not be impregnated while asleep, if it is possible for her not to be roused. In a preternaturally sound sleep this appears to have been accomplished.[q]

Many women menstruate during the first five months of pregnancy. Heberden mentions one who always menstruated the whole nine. She had lain in four times.

Women sometimes menstruate during suckling; but when this happens, it is not generally till two or three months have elapsed after delivery.

The reason that menstrual blood does not coagulate is its want of fibrin: it is, therefore, really not blood. "It has the properties," says Mr. Brande, "of a very concentrated solution of the colouring matter of the blood in a diluted serum."[r] When the catamenia are suppressed, a bloody fluid is sometimes periodically discharged from the aerial or alimentary canal, or even from ulcers, or some sound part of the skin.

To regard women during menstruation as unclean, is certainly very useful, though the custom among the American women of leaving their husbands' tents at this period for separate hovels, is

[k] *Médecine Légale*, t. i. p. 393.

[l] *Traité complet des Accouchemens*, p. 53.

[m] *Phil. Trans.* 1812. p. 11.

[n] *Med. Chir. Trans.* t. xiii. p. 347.

[o] *Commentarii de morborum historia et curatione*, cap. 43.

[p] *Sur les Fonctions du Cerveau*, t. iii. p. 253.

[q] See the *Causes Célébres* of Foderé (l. c. t. i. p. 500. sq.) for an account of a priest and what he thought a dead body.

[r] *Phil. Trans.* 1817.

said by Hearne to give a pretence for quitting the good men whenever they are sulky, — even twice or thrice in a month.[r] Moses set a woman apart for seven days, and enacted, that any one who touched her, or even any thing she had sat upon, should wash his clothes and be unclean till evening; and if he lay with her, should be unclean for seven days.[s] But menstruating women have been regarded as mysteriously deleterious. The Americans forbid them to walk near where there is fishing or hunting, or to cross the path where deer, &c. have been carried, lest success should be averted. In Pliny,[t] a menstruating woman is declared the most pernicious thing in the world, — blighting fruit, destroying grafts, and hives of bees, drying up fields of corn, causing iron and copper to rust and smell, driving dogs mad, and disgusting even ants with their food, &c. &c. In this country it is firmly believed by many that meat will not take salt if the process is conducted by a menstruating woman.

Gall says that, when he practised at Vienna, "he soon noticed that during a certain time no women menstruated, and at another a great many menstruated at once. As this frequently occurred, it excited his attention, and made him fancy that perhaps menstruation followed some law. He therefore kept a journal, in which he marked the periods of a considerable number of women for many years. It resulted that women are divided into two great classes; each class having a different period. The women of the same class all menstruate within eight days; after this time, an interval of ten or twelve days follows, in which very few women menstruate. At the end of these eight days begins the period of the second great class, all the individuals of which also menstruate within eight days. Suppose a woman of this class begins to menstruate on the first of the month, she will have finished on the eighth, if her catamenia continue eight days. Another, whose catamenia last but three days, will finish on the third; or, in case she did not begin till the fifth, she equally will finish on the eighth, and so the rest; all who are regular, having an interval of twenty-one, twenty-five, or twenty-six days. The following are the two periods of women, each belonging to a different class, such as they really occurred. In 1818: January 19, 3; Febru-

[r] *Journey from Prince of Wales Fort to Hudson's Bay*, &c. 1795. p. 313. sq.

[s] *Leviticus*, xv.

[t] *Hist. Natur.* vii. 13.

ary 16, 1, 29; March 14, 28; April 10, 25; May 8, 23; June 5, 30, 19; July 26, 17; August 21, 13; September 18, 9; October 16, 8; November 14, 5; December 12, 2. It appears that each woman menstruated thirteen times in the year; and that she who began on the 3d of January, menstruates for the fourteenth time on the last of December.

"There are always women who, through some accidental cause, have menstruated out of these two great periods; but after one or two months they usually return to the class to which they belong. Women out of health, young persons who have not yet fully completed their growth, and women who are near the final cessation of the catamenia, are the most subject to these irregularities.

"During my travels I continued my journal; and what struck me the most was, that the two periods coincided in all countries, at least in Europe. At the same time that women menstruated in Vienna, Berlin, Hamburgh, and Amsterdam, they menstruated also at Bern, Copenhagen, Paris," &c.[u]

[u] *Sur les Fonctions du Cerveau*, t. iv. p. 355. sqq.

SECT. XXXIX.

OF CONCEPTION AND PREGNANCY.

559. We now come to the functions for which the genital organs are given us, — to conception and the propagation of the species, in treating of which, we shall first merely describe the phenomena that are observed in that admirable and truly divine process, and afterwards investigate the powers by which they are produced.[a]

560. In the first place, it is worthy of remark that the human race, unlike most animals, does not copulate at certain periods of the year,[b] but that with it every season is equally favourable to the flame of love.

561. When a woman receives a man[c] and both burn with that animal instinct which is superior to all others in universality and violence, the uterus, swelling I imagine with a kind of inflammatory orgasm,[d] and animated by its vita propria (547), draws in, as it were, the semen ejaculated by the male,[e] and appears to pour forth a fluid of its

[a] On all the subjects of this section, consult, among many others, Fr. B. Osiander, *Observationes de homine, quomodo fiat et formetur*, in the *Comment. Soc. Reg. Scientiarum recent.* vol. iii. p. 25. vol. iv. p. 109.

[b] Unless the observation first made by Wargentin, in Sweden, — that there is a greater proportion of births in September, which corresponds to the preceding December, be considered as relative to this point. *Swensk. Vetensk. Acad. Hadlingar.* 1767. vol. xxviii. p. 249. sq.

[c] Of the various circumstances of this admission, I have spoken in my work *De gen. hum. variet. nat.* p. 17. sq. 3d edit.

[d] *v.* the two instances of uteri seen by Ruysch, immediately after impregnation. The one of a common woman, murdered by her paramour immediately after connection. *Adversar. Anat. Med. Chirurg.* Dec. i. tab. ii. fig. 3. The other of a married woman, impregnated a few hours previously, and killed in the act of adultery by her husband. *Thesaur. Anat.* vi. p. 23. sq. tab. v. fig. 1.

[e] If we consider the impetus with which the semen is emitted, and, as it were, swallowed by the uterus, and how small a quantity is proved, by experiments on

own against it (552); the tubes become rigid, and their fimbriæ embrace the ovaria, in one of which a ripe Graafian vesicle bursts like an abscess, and its albuminous drop of fluid, being absorbed by the abdominal opening of the tube, is conveyed to the womb.

562. After the escape of this drop from the ovarium, the lips of the wound are closed by an external cicatrix, and the vascular membrane which contained the drop is converted into a *corpus luteum.*[f] This is at first hollow, and full, as appears to me, of a plastic lymph,[g] which in progress of time becomes a fleshy nucleus,[h] surrounded by a thick, remarkably vascular, cortex.[i] (A)

563. After the impregnation of the womb, the canal which runs along the cervix of the uterus is thoroughly closed, especially towards its superior or internal orifice (544), so that superfœtation, properly so called,[k] cannot naturally take place. There are scarcely any constant and infallible signs

---

brutes, to be sufficient for impregnation, we shall be able to explain those well established cases of conception, where the hymen was imperforate, — cases commonly brought forwards in support of the existence of a *seminal aura.*

[f] See J. Chph. Kuhlemann, *Observat. circa negot. generat. in ovib. factæ.* Gotting. 1753. 4to. c. *f. ae.*

[g] See Everard Home's contrary opinion respecting the origin of the corpus luteum and its relation to the ovum, *Phil. Trans.* 1817. p. 255. and 1819. p.59.

[h] See W. Hunter, *Anatomy of the gravid uterus.* tab. xv. fig. 5. tab. xxix. fig. 3. tab. xxxi. fig. 3.

[i] It is a celebrated question, of great importance both in physiology and forensic medicine, and much agitated in late years, whether a corpus luteum is the consequence of a fruitful coition only, and therefore an infallible sign of conception, or whether it may occur independently of coition, and therefore exist in virgins. We trust that we have established the truth of this point, and shown the conditions under which a corpus luteum may occasionally be formed even in virgins. *Specimen physiologiæ comparatæ inter animantia calidi sanguinis vivipara et ovipara,* in the *Commentat. Soc. Reg. Scientiar. Gotting.* vol. ix. p. 109. sqq.

[k] That different conceptions may occur from the repetition of copulation after very short intervals, is proved by the instances of adulterous women who have brought forth twins resembling different fathers in the colour of their skin: *viz.* of black women who have brought forth a black and a mulatto, and of European women who have brought forth a white and a mulatto. (B)

by which the woman herself can be very certain of the changes that occur within during conception.[l]

564. The internal surface of the uterus becomes lined with plastic, and, as it were, inflammatory, lymph (15), which forms the tunica *caduca* or *decidua* of Hunter.[m] This is said to consist of two laminæ, — the *crassa*[n] investing the uterus, except at the orifices of the tubes and of the canal of the cervix,[o] — and the *caduca reflexa*,[p] so denominated from being, after the ovum begins to be formed and to take root in the decidua, continued over the other parts of the ovum, just as the peritonæum is continued over the abdominal viscera.

565. The *ovum* is produced before the embryo which it is intended to contain, but scarcely[q] begins to be formed earlier than the second week from conception. (C)

566. This ovum consists,[r] besides the external accessary

[l] Ad. El. Siebold, *De diagnosi conceptionis et graviditatis sæpe dubia.* Wirceb. 1798. 4to.

Gm. Theoph. Kelch, *De symptomatibus et signis graviditatis earumque causis.* Regiom. 1794. 4to.

[m] Aretæus Cappadox (*De Causis et Sig. Morb. Diuturn.* l. ii. c. ii. p. 64. sq., Boerhaave's edition), seems the first who gave a true account of the origin of this membrane, the more accurate knowledge of which we owe to Wm. Hunter.

After the revival of anatomy, Fallopius restored the knowledge of it. *Observ. Anat.* p. 207.

It is the *chorion*, either simply called so, or the *spongy, tomentous, fungous, filamentous, reticulated*, of the following age; the *involucrum membranaceum* of B. S. Albinus.

The first delineation of it was given, as far as my knowledge extends, by Ruysch. *Thes. Anat.* v. tab. i. fig. 1. F.B.C.G.

[n] This is called *cribriform* by the distinguished Fr. B. Osiander.

[o] W. Hunter, l. c. tab. xxxiv. fig. 3—6.

Home, *Phil. Trans.* 1817. tab. viii.

[p] By Osiander, the membrane, *ovi crassa.* See B. S. Albinus, *Annotat. Acad.* l. i. tab. iii. fig. i. e. W. Hunter, l. c. tab. xxxiii. fig. 1—4.

[q] Ever. Home and that admirable artist Francis Bauer give an engraving of an ovulum, thought to be only of eight days. *Phil. Trans.* l. c. tab. viii. and xi.

[r] Respecting the membranes of the ovum, and their connection with the uterus and embryo, vide J. F. Lobstein, *über die Ernährung des Fœtus.* Halle, 1804. 8vo.

covering afforded by the *caduca* of Hunter, of two proper velamenta or membranes.

Of an exterior — the *chorion*[s] of the moderns, the external surface of which is, from the first, nearly covered with inexpressibly beautiful knotty flocculi; whence it has been called the *flocculent*, *leafy*, or *mossy*, *chorion*. By means of these flocculi, which are the rudiments of the fœtal portion of the future *placenta*, the ovum takes root, as it were, in the uterine decidua. (564)

Of an interior, — styled *amnion*,[t] possessing no blood-vessels (5), delicate, but remarkably tough.

567. These two proper membranes of the ovum differ very much from each other in size the first week after the formation of the ovum; the chorion appears a large bladder, to the interior of which the amnion, like a much smaller bladder, adheres in that part only which nearly corresponds with the centre of the external flocculent surface of the chorion.

The remaining space between the chorion and amnion is filled by a clear water, which may be called the *liquor chorii*, of doubtful origin and short duration.

For, since the amnion increases more rapidly than the chorion, and approximates to the latter even during the first months after conception,[u] in proportion to its approximation must this fluid necessarily be absorbed.

568. The internal membrane of the ovum is filled, from its first formation (565) to the last moment of pregnancy, with the *liquor amnii*,[x] an aqueous fluid, of a yellowish colour, nearly inodorous, of a bland and scarcely saltish taste, and

[s] The *Membrana media* of Rouhault, Haller, &c., the *vasculosa* of Osiander.

For the various synonyms and homonyms of the membranes of the ovum, consult Haller, *Elem. Physiol.* vol. viii. P. i. p. 194. sq. and Tabarrani's letter to Bartaloni, *Atti di Siena*, t. vi. p. 224. sq.

[t] The *membrana tenuis* of Osiander; in French, *la coiffe*.

[u] See Hunter's figures (imaginary indeed), l. c. tab. xxxiv. fig. 9. 8. 7.

[x] Paul Scheel, at the end of his *Commentat. de liquoris amnii asperæ arteriæ fœtuum humanorum natura et usu.* Hafn. 1799. 8vo.

C. H. D'Zondi, *Supplementa ad anat. et physiolog. potissimum comparatam.* Lips. 1806. 4to.

compared to albumen, from which, however, more accurate investigation proves it to differ considerably.[y]

Its source is doubtful and cannot be referred to the fœtus or umbilical chord, because it exists in abortive ova containing neither.

Its quantity is inversely as the size of the fœtus.

Hence we may conjecture that its use is rather to defend the fœtus while nearly gelatinous and most liable to suffer from external injuries, than to afford nourishment, which latter opinion is, indeed, refuted by the numerous instances of full-grown and well-fleshed fœtuses *destitute of a head.*[z]

569. The EMBRYO[a], which swims in this fluid, suspended by the umbilical chord, like fruit by its stalk, begins to be formed about the third week after conception:[b] at first it appears of rather a globular shape, resembling a little bean or kidney, from which the rudiments of the extremities grow, and on which the face is at length formed, &c.[c]

[y] Steph. J. Van Geuns, *De natura et utilitate liquoris amnii.* Ultraj. 1793. 4to.

[z] Consult the distinguished Tiedemann, *Anatomie der Kopflosen Missgeburten.* Landshut, 1813. fol. p. 52. D. Welge, a medical practitioner at Goslar and formerly a favourite pupil of my own, has enriched my museum with an excellent example of this kind, *viz.* a twin female fœtus without head, arms or thorax, born (what is particularly worthy of notice) *alive,* after a perfect and vigorous sister; for it repeatedly extended and bent its legs before it perished, on being seized with a general horripilation.

[a] C. Fr. Burdach, *De primis momentis formationis fœtus.* Regiom. 1814. 4to.

[b] There is no occasion in our times to refute the false remarks and figures, published by Mauriceau, Kerckring, and others, of fœtuses, one or a few days old.

The reasons of my fixing upon this term, I have explained at large in the *Medicin. Bibliothek.* vol. ii. p. 673. sq.

How remarkably this was afterwards confirmed by fact, will be found in the same work, vol. iii. p. 727.

[c] Those who have not an opportunity of inspecting the fragile primordia of our race, may consult the excellent plates in Ruysch's *Thesaur. Anat.* vi. tab. ii. fig. 2, 3, 4, 5. 8. 10. *Thesaur.* x. tab. iii. fig. 1.

Also B. S. Albinus, *Annotat. Acad.* l. i. tab. v. fig. 4, 5.

Trew, *Commerc. Litter. Noric.* 1739. tab. iii. fig. 4, 5.

Abr. Vater, *Mus. anatom. propr.* tab. viii. fig. 2. 4, &c.

And, instar omnium, Sömmerring's *Icones Embryonum Humanor.* Francof. ad Mœn. 1799. fol.

570. By nature woman is *uniparous*, conceiving but one fœtus. Frequently, however, she produces twins, the proportion of which to single births, Süssmilch estimates as 1 to 70.[d] In these cases, each child has usually its own amnion, whereas there is a common chorion.[e]

571. The medium of connection between the mother and child are the umbilical chord and the placenta into which it is distributed.

572. The *umbilical chord*, which appears coeval with the embryo, varies exceedingly in length and thickness, in the place of its insertion into the placenta, in its varicose knots, &c. It always consists of three blood-vessels twisted spirally together, viz. a vein running to the liver of the fœtus, and two arteries arising from its internal iliacs or hypogastrics. They are separated from each other by cellular septa of various directions,[f] and are throughout narrowed internally by nodules or the *quasi-valves* of Hoboken.[g]

They are collected into a chord by means of a cellular membrane, which is full of a peculiar, very limpid fluid, called Whartonian, resembling gelatin in appearance, and is surrounded externally by a continuation of the amnion.

573. At the part of the chord which is united to the fœtus, there enters the *urachus*[h] between the two umbilical arteries

[d] The proportion is not very constant, and is liable to national variety. (D)

Egede expressly mentions the infrequency of twins among the Greenlanders, *Descr. du Groenland*, p. 112.

Their remarkable frequency, on the contrary, among the people of Chili is asserted by Molina, *Saggio su la Storia Naturale del Chili*, p. 333.

[e] See Denman, *Engravings tending to illustrate generation and parturition.* Lond. 1787. fol. tab. ix.

Twins are very rarely contained in a common amnion. Vide J. de Puyt, *Verhandel. der Zeeuwsch Genootsch. te Ulissingen*, t. ix. p.423. sq.

Consult Hor. Garneri, *Mém. de l'Acad. de Turin*, 1809. Append. p. 89.

[f] W. Noortwyk, *Uteri Humani Gravidi Anatome*, tab. iii. fig. 5. 6. 7.

[g] Hoboken, *Anatome secundin. human. repetita*, p. 522. sq. fig. 38. 39. 40.

This structure is further displayed in the arterial branches of the placenta by Aug. Chr. Reuss, *Nov. Observ. circa Structur. Vasor. in Placenta Humana.* Tubing. 1784. 4to.

[h] J. Noreen, *De Uracho.* Gotting. 1749. 4to.

Ph. Ad. Boehmer on the same, at the end of his *Anatome ovi hum. fœcund. sed deformis.* Hal. 1763. 4to.

(486), and it arises from the fundus of the urinary bladder. In the human subject, it is pervious but for a very short distance, and, indeed, soon disappears altogether. In many other species of mammalia it leads to the allantoid,[i] which the human fœtus does not possess. For I think that the problematical *vesicula umbilicalis*, found in human ova between the chorion and amnion,[k] is not analogous to the allantoid[l] but to the *tunica erythroides* which is seen in the ova of some mammalia, and to the vitellary sac of the incubated egg. It is found in healthy human ova, the second or third month after conception, too frequently and of too constant an appearance to be regarded as accidental, morbid, or monstrous.[m]

574. The blood-vessels of the chord pass to the *placenta*, of whose origin from the leafy surface of the chorion that is united to the DECIDUA CRASSA, we formerly spoke. Hence we discover how the substance of the placenta is double,—

[i] Vide Fabr. ab Aquapendente, *De Formato Fœtu.* tab. xii. xiii. xiv. xvii. fig. 27. xxv.

[k] Vide *Commentat. Soc. Reg. Sc. Gottingens.* vol. ix. p. 128. fig. 1.

[l] Among the moderns who still compare it to this, are J. F. Lobstein, l. c. *über die Ernährung des Fœtus.*

And C. H. D'Zondi, *Supplem. ad Anat. et Physiol.*

[m] The opinions both respecting the natural constancy of the vesicula umbilicalis and its analogy to the *tunica erythroides*, I originally, as far as I know, proposed thirty-four years since, in the first edition of these Institutions (1787), and in my *Specimen Physiologiæ Comparatæ* (1788) formerly quoted.

The connection of this vesicle with the intestinal canal of the embryo, and indeed with the appendix vermiformis of the cæcum, is shown by Laur. Oken in his and Diet. G. Kieser's *Beytr. zur Vergl. Zoologie*, &c. Fasc. i. ii. Bamberg. 1806. sq.

See likewise Kieser's *Ursprung des Darmkanals aus der vesicula umbilicalis, dargestellt im menschlichen Embryo.* Goett. 1810. 4to.

But, on the contrary, Fr. Meckel shows it to be united with the diverticulum of the small intestines (Diverticulum Littrianum), *Beytr. zur Vergl. Anatomie.* vol. i. fasc. i. Lips. 1808. p. 93.; and more fully in Reil and Autenreith's *Archiv. für die Physiologie*, vol. ix. p. 421.

Consult, among many others, W. Hunter, *Anatomical Description of the Human Gravid Uterus* (a posthumous work edited by Matthew Baillie). Lond. 1794. 4to. p. 40. sq.

B. N. G. Schreger's *Letter* to Sömmerring, *De functione placentæ uterinæ.* Erlang. 1799. 8vo.

the uterine portion derived from the decidua and forming a spongy parenchyma, the fœtal arising from the umbilical vessels distributed on the chorion.

The increase of the ovum is irregular, the smooth part of the chorion growing more rapidly than the mossy; consequently, the size of the placenta bears a greater proportion to that of the ovum, the shorter the time that has elapsed since conception, and a smaller, as the period of labour approaches.

As pregnancy advances, its texture becomes gradually more compact; furrowed and lobular on its external surface, which lies towards the uterus, and smooth on the inner surface, which is covered by the amnion and lies next the fœtus. It varies greatly in size, thickness, figure, and situation, or place of attachment to the uterus; generally it adheres to the fundus; it is equally destitute of sensibility and true irritability.

575. Although all agree that the placenta is the chief instrument in the nourishment of the fœtus, the true mode of its operation, and its mutual relation to the uterus and fœtus, have given rise to great controversies in modern times. After all, the truth appears to be this, — that no anastomosis exists between the blood-vessels of the uterus and of the chord, but that the oxygenised blood which proceeds from the uterus to the portion of the placenta that was originally the decidua crassa, is absorbed by the extreme radicles of the umbilical vein distributed upon the mossy chorion, and carried to the great venous trunk of the chord; while the carbonised blood returning from the fœtus, through the umbilical arteries, being poured in the same manner into the substance of the placenta, is absorbed by the venous radicles of the uterine portion of the placenta, and returned to the uterus.

This account is supported by very careful but fruitless attempts to inject the umbilical by means of the uterine vessels, and the uterine by means of the umbilical; or to tinge the bones of the fœtus with red, by giving madder to the mother during pregnancy. It is also confirmed by the difference observable between the blood of the mother and fœtus. (E)

576. During the progress of pregnancy, while the fœtus and secundines are increasing, the uterus of course undergoes important changes,[n] not only in size, but in situation, figure, and especially in its texture, which is considerably changed both with respect to its blood-vessels and the intervening parenchyma, from the constant and great congestion of fluids that occurs in it.

In proportion as the uterus increases, the blood-vessels from being tortuous and narrow become more straight[o] and capacious, and the veins, near the termination of pregnancy, acquire so great a bulk[p] as to have been taken for sinuses by some anatomists.

The parenchyma becomes gradually more thin and lax,[q] especially in the part nearest the ovum, so that although the gravid uterus is very thick, particularly at its fundus, and in a living and healthy woman is turgid with blood and replete with vital energy, nevertheless it is soft, and its general nature, (especially after death, when, as Arantius long since remarked, it almost appears lamellated if pregnancy was advanced,[r]) extremely different from the firm and compact substance of the unimpregnated uterus.

577. The remaining important changes[s] of the gravid uterus, as well as those still more remarkable ones which occur to the ovum and fœtus, we will briefly relate in the

[n] L. Ph. J. Pott, *Commentatio præmio regio ornata de corporis fœminæ gravidæ mutationibus*, &c. Gott. 1815. 4to.

W. Wagner, on the same subject, *Commentatio quæ secundam palmam tulit.* Brunsv. 1816. 8vo.

[o] *v.* W. Hunter, *Anat. Uteri Gravidi*, tab. xvi.

[p] Ibid. tab. xviii.

[q] *v.* B. S. Albinus, *Annotat. Acad.* i. ii. tab. iii. fig. 2.

[r] Arantius, *De Humano Fœtu libellus*, p. 5. sq. 1579. Compare B. S. Albinus, *Tab. Uteri Gravidi*, ii.

[s] Among others consult J. Burns, *Anatomy of the Gravid Uterus*. Glasgow. 1799. 8vo. — a work carefully and faithfully executed.

order of the ten lunar months according to which pregnancy is at present very conveniently calculated.

578. As the uterus immediately after impregnation always becomes turgid, (561) so, increasing from that period in bulk and weight, it descends rather lower into the upper part of the vagina, still retaining its former figure during the first three months, except that its fundus becomes a little more convex and its anterior portion somewhat recedes from the posterior, and that its cavity, before extremely small and nearly triangular, becoming expanded by the fluids of the ovum, accommodates itself to the subglobular form of the latter.

The ovum itself, which about the termination of the first month is of the size of a pigeon's egg, and possesses both deciduæ separate from each other, and the minute amnion separate from the larger chorion, commonly attains, near the end of the third month, the size of a goose's egg; the decidua reflexa then very closely approaches to the crassa, and the amnion to the chorion; the former is filled with the large quantity of fluid which bears its name and defends from the pressure of the womb the tender embryo that is now very small in proportion to it, scarcely indeed equal in size to a young mouse, and hanging headlong and rather unsteadily.[t]

579. From the fourth month, the uterus becomes more oval or subglobular, and, its neck gradually softening, shortening, and almost disappearing or rather extending laterally, it again tends upwards and begins to rise to the superior part of the pelvis. At the same time the tubes ascend with the convex fundus of the uterus, and are extended and elongated, but adhere to the sides of this organ so firmly, that half of their length only is separate from it, and, at first sight, they appear to arise from the middle of it, — a circumstance which gave occasion to an erroneous opinion of the enormous increase of its fundus.

After this period, the fœtus acquires a size more proportional to the capacity of the ovum, and becoming, at the same

[t] v. Doeveren, *Specimen. Observ. Academ.* p. 104. sq.

time, conglobated together, acquires a more fixed situation, which it preserves to the end of pregnancy; the head is inclined to the chest, and the back bent and generally placed rather towards one side of the mother.

580. In the middle of pregnancy, — at the end of the fifth month, so much has the uterus increased, that its fundus is nearly between the navel and pubes, and pregnancy becomes externally evident.

From this period, the fœtus by its motion is generally more distinctly perceptible to the mother: this circumstance, however, occurs at no definite time.

581. The uterus and fœtus continuing to increase during the remaining five lunar months, the fundus of the former reaches the umbilicus about the sixth month; after the eighth, having risen higher, it approaches the scrobiculus cordis. In the mean time, the cervix is gradually obliterated, flattened, and attenuated.

582. In the tenth month, the uterus, overwhelmed, as it were, with its own bulk, — being eleven inches in length and nine or more in breadth, begins again to sink.

Each decidua, but especially the reflexa adhering to the chorion, having for many months been growing thinner, now almost appears a net-work of short white fibres. [u]

The larger diameter of the placenta is now nine inches; its thickness one inch; its weight one pound or upwards.

The length of the umbilical chord is generally eighteen inches or more, — which is considerable if compared with that of other mammalia.

The weight of a common full grown fœtus is usually about seven pounds; its length about twenty inches. [x]

[u] On the various appearances of the decidua during the latter half of pregnancy, consult W. Hunter, *Anat. of the gravid uterus*, tab. xxiv. fig. 3, 4. tab. xxix. fig. 45. comparing with these, tab. xxix. fig. 2.

[x] This weight and volume are remarkably large in proportion to the mother, if compared with those of the offspring of many other mammalia. But, notwithstanding that, woman is so far from producing the largest fœtus in this respect among the mammalia, that she is far surpassed by some, especially of the bisulca, and most by the Savia pig.

The quantity of the liquor amnii is too variable to be defined; but, when the fœtus is strong, it seldom exceeds a pound.

NOTES.

(A) The important contents of this and the preceding paragraph demand farther attention.

Several questions occur. 1. What is the state of the female organs during the vehemence of desire? 2. How far does the semen masculinum penetrate? 3. Do the Graafian vesicles burst from the influence of the semen masculinum, or from mere excitement, the semen impregnating only the contents of the vesicles after their escape from the ovaria? 4. At what period do the Graafian vesicles burst?

1. Mr. Cruikshank, on inspecting the genitals of a female rabbit during heat, observed appearances nearly similar to those described by Harvey, Graaf, Ruysch, Diembroeck, &c.[y] He found them all prodigiously turgid with blood; the vagina was absolutely of a dark mulberry colour, and on the ovaria were prominent spots which injection proved to be vascular and which were swollen Graafian vesicles; the contents of the vesicles, however, remained transparent: the Fallopian tubes were also nearly black, writhing in an extraordinary manner, having a strong peristaltic motion, and embracing the ovaria with their fimbriated extremity so closely as to lacerate on an attempt to disengage them.[z] These observations were all confirmed by Mr. Saumarez.[a] During copulation, this state of the organs must be carried to the highest pitch of intensity.

2. Harvey could never detect semen in the uterus after copulation.[b] Nor De Graaf in the vagina.[c] Verheyen found a large quantity in the uterus of a cow, six hours after copulation.[d]

[y] Boerhaave, *Prælectiones Academicæ*, with Haller's notes, t. vi. p.113. sq.

[z] *Phil. Trans.* 1797.

[a] *A new System of Physiology*, &c. vol. i. p. 337.

[b] Harvey, *De Generatione*, p. 228, &c.

[c] Regn. De Graaf, t. i. 310.

[d] Verheyen, *Sup. Anat.* tract. 5. cap. 3.

Galen always discovered it in the uterus of brutes after copulation.[e] Leeuwenhoeck, in the case of rabbits. Ruysch found it not only in the uterus, but in the Fallopian tubes of two women killed soon after connection.[f] Postellus, Riolan, Carpus, and Cheselden also believed they found it in the uterus.[g] Haller once found it in the uterus of a sheep, forty-five minutes after coition.[h] Fallopius frequently found it in the tubes.[i] Haller very justly remarks that some of those who believed they saw semen in the uterus, probably saw mucus only. He inclines, however, with almost all physiologists, to the opinion that the semen does enter the uterus. The length of the penis, the force of emission, the peristaltic action of the vagina during the heat of some brutes,[k] the existence of a bifid glans with two orifices in the penis of the males of some species the females of which have two ora uteri,[l] are circumstances of no little weight in favour of the opinion that the semen does penetrate at least into the uterus. Mr. Hunter, however, actually saw it projected into the uterus of a bitch which he killed by dividing the spinal marrow while she was united with the male.[m]

[e] Galen, *De semine*, lib. i. c. 2.

[f] *Thes. Anat.* and *Adversaria Anat. Medic. Chirurg.*

[g] Boerhaave, *Prælect. Acad.* Haller's note to p. 182. t. 6.

[h] Haller, *Elementa Physiol.* t. 8. p. 22.

[i] *Opera*, i. fol. m. 421.

[k] See, for instance, Dr. James Blundell, in the *Med. Chir. Trans.* vol. x. p. 266.

[l] Account of the structure of the Wombat, by Sir E. Home. *Phil. Trans.* 1798.

[m] Home, *Phil. Trans.* 1817. Saumarez, l. c. p. 429.

Mr. Saumarez observed in two instances, when two hours and a half only had elapsed after coition, and before corpora lutea were formed, globular, pearl-coloured bodies, as large as a pin's head, which, on being squeezed, burst and discharged a very subtle fluid to some distance. Dr. Haighton commonly met with them. Whether these were semen, having undergone some change, is uncertain.

The well known instances of conception, where the admission of the male organ into the vagina was prevented by the great strength of the hymen, are sometimes cited against the opinion that the semen passes beyond the vagina, but certainly with no weight. 1. Because the most minute portion of semen is sufficient to impregnate: — Spallanzani mixed three grains of frog's semen with a pound and a half of water, and with a little of this mixture fecundated nearly all the numerous posterity contained in the threads taken from the female; and, after mixing three grains with even twenty-two pounds of water, he fecundated some. (*Dissertations*, vol. 2. p. 191. English transl.) 2. Because the vagina has an

Dr. Haighton, with the view of ascertaining whether it is necessary to impregnation that the semen pass along the Fallopian tubes, made a number of experiments on the effects of tying and dividing them in rabbits at different periods relative to coition.[n] The peristaltic action of the tubes, and their adhesion to the ovaria during the venereal ardour, argue strongly in favour of the semen being conveyed along them, because we can hardly suppose these circumstances to begin to occur at this period for the purpose of conveying the contents of the Graafian vesicle, as this does not burst till a considerable time after copulation. Dr. Haighton, indeed, says that these changes in the tubes did not take place in his experiments (all made, however, after copulation), till long (forty-eight hours) after copulation, — till the ovaria were about to discharge into them their vesicular fluids. In this he agrees with Bartholin, De Graaf, Schurig, Deswig, and Lang, who maintained, like him, that the semen, at least as far as examination went, does not enter the tubes.[o] But Mr. Cruikshank and Mr. Saumarez, two of the latest experimenters, assert the contrary in the detail of their experiments, and, as Haller remarks of the old partisans, the negative experiments of the former cannot overturn the positive testimony of the latter, — " Eorum experimenta *negativa* non possunt affirmantium fidem evertere :" Sbaragli, Verheyen, Hartman, and Duverney, could find no *change* in the state of the tubes at any time, although their negative observations are completely overthrown by the positive observations of all others who have enquired experimentally into the subject. Besides, the great abundance of blood in the genital organs, during the sexual ardour, must cause the tubes to enlarge and apply themselves to the ovaria : this, as Haller mentions upon the

---

action of its own sufficient to move the semen onwards to the uterus : — it is seen during the œstrum of brutes (and also the uterus in a lower degree) to have a peristaltic movement ; it often firmly embraces the human placenta ; and Dr. Hamilton, the present obstetric professor of Edinburgh, mentions, in his lectures, having attended a physometric patient whose vagina sucked up air from without, as appeared from the emission of air ceasing in the warm bath, and Dr. Monro (secundus), likewise, was perfectly satisfied that the woman drew in the air. Any canal supplying the place of vagina, however small, probably executes the same absorbing action, or convey the influence of an absorbing action of the womb.

[n] *Experimental Enquiry*, &c. by John Haighton, M.D. *Philos. Trans.* 1797.

[o] Haller, *Elem. Physiol.* and notes to Boerhaave, l. c.

authority of Hartsoeker, occurs even in the dead body by means of injection.

Dr. Haighton, however, to prevent the semen from passing along the tubes, divided one of them in virgin rabbits, and, after the wound was healed, admitted the animal to the male. The ovarium on this side contained corpora lutea equally with the other, proving that the Graafian vesicles had burst, although the semen could not possibly have reached the ovarium.[p] No fœtus, notwithstanding, was discoverable in any instance: on the other side (for in the rabbit the uterus is double) fœtuses were found equal in number to the corpora lutea. Dr. Haighton concludes that impregnation may take place without the advance of semen along the tubes. And his conclusion is perfectly just, according to his test of impregnation, — the escape of the contents of a Graafian vesicle. But I apprehend this to be no more deserving the title of a test of impregnation than the emission of the semen masculinum. Impregnation is that change wrought by means of the male semen in the contents of a Graafian vesicle, which enables them to become a fœtus. Now this was never effected when the tube was divided: — although the presence of corpora lutea proved vesicles to have burst, yet a fœtus was in no one instance discovered: in other words, the contents of the Graafian vesicles were in no one instance impregnated. Hence I conclude, with the old physiologists before the time of Harvey, that the conveyance of semen beyond the vagina, — where it may come in contact with the contents of an ovarian vesicle, is absolutely requisite to impregnation; and perhaps the state of the tubes during the heat of some brutes (page 478), and the occasional growth of fœtuses in the tubes, abdomen, and in the ovaria themselves,[q] render it

[p] The divided end of the tube was found totally impervious. The experiment succeeded when one tube only was divided: the division of both deprived the animal not only of fertility but of sexual desire, and caused the ovaries to shrink, and even the division of one had this effect in some instances. If the tube was divided after coition, the result was the same, provided the operation was performed before the contents of the vesicles had entered it; for, if too much time had elapsed, the ova were transmitted to the uterus and grew to maturity.

[q] The fœtus has frequently remained in the ovarium. See, for instance, the *Phil. Trans.* 1680-3. and 1797 and 1820; also Schurig's *Embryologia*, p.824. sq. where Bohn, Grundius, Ortlob, Blasius, and Littre, are quoted.

Such cases do not militate against the probability of the approximation of the semen masculinum to the ovarian contents being necessary for impregnation, likely that the semen passes even into the tubes. But Dr. Haighton's experiments were unnecessary for this conclusion, because pathological observation proves sterility to be an invariable consequence of complete obstruction in any point between the os externum and ovaria,—in the Fallopian tubes, in the uterus, or in the vagina.[r]

When the obstruction in such cases is so far within as to allow the deposition of the semen, the sterility disproves the notion of Bartholin and Stenonis,—that this fluid operates by absorption.

3. Dr. Haighton imagines that the bursting of the vesicle is the sympathetic effect of the semen in the vagina or uterus.[s] Now

---

because the tenuity of the vesicles, when ready for this operation, is such as we may suppose presents no barrier to the influence of the male upon the female fluid, especially if we reflect that oxygen and blood affect each other through a piece of moistened bladder (Sect. II. (G). Indeed it is possible, even, that the vesicle bursts and the two fluids come into actual contact, but that imperfect rupture or some other cause detains the ovarian fluid till it has acquired permanent adhesions.

[r] Schurig, *Gynæcologia*, pars ii. p. 172. Morgagni, Ruysch, &c. &c.

Dr. Blundel has repeated his uncle's experiments, with this variation, that he produced the obstruction not in the tubes, but in the uterus or vagina. Impregnation was of course equally prevented and the ovarian vesicles burst as usual. *Med. Chir. Trans.* vol. x.

[s] "That the semen first stimulates the vagina, os uteri, cavity of the uterus, or all of them.

"*By sympathy*, the ovarian vesicles enlarge, project, and burst.

"*By sympathy*, the tubes incline to the ovaria, and having embraced them convey the rudiments of the fœtus into the uterus.

"*By sympathy*, the uterus makes the necessary preparations for perfecting the formation and growth of the fœtus, and,

"*By sympathy*, the breasts furnish milk for its support after birth."

There is reason, however, from one passage, to suppose that Dr. Haighton believes the semen to pass no farther than the vagina. After dwelling upon the opinion opposite to his own, he says, "The difficulties which were opposed to the conveyance of the semen by the tubes, were, as we should expect, intended to prepare the way for a different explanation; therefore physiologists, by a very natural transition of thought, were led to suppose that the presence of semen in the *vagina alone* was sufficient to account for impregnation:" and he immediately proceeds to relate his experiments. In fact I know this to be his opinion, because in a MS. of his lectures that I rendered full and accurate by taking my notes in Latin, I find it said of Haller for believing that the semen always enters the uterus, "Now it is surprising that a man like Haller should do so, who, from his works would seem to form his opinions, in general, on sound reasoning:" and Ruysch's cases are quite ridiculed, because this anatomist, "being now of an age although on the side where the tube was divided the ovarium did discharge the contents of some vesicles, it is not proved to have done this through the operation of the semen. The venereal ardour alone was shown in the observations of Mr. Saumarez as well as in those of Mr. Cruikshank (and the same has been remarked in the human female)[t] to produce, among the other great changes of the sexual organs, the enlargement of the vesicles. Nay we are certain that it will occasion the rupture of the vesicle without any commerce with the male. The hens of poultry lay eggs (incapable indeed of being hatched), although separated from the cock,—a circumstance proving that in them the œstrum is sufficient to enlarge and burst a vesicle, apply the tube to the ovarium, and occasion it to convey away an ovum. Aristotle and Harvey relate that many birds lay eggs from mere titillation; the latter proved it experimentally in the thrush, in the sparrow, and in a favourite parrot belonging to his wife. Blumenbach is satisfied with the accuracy of the accounts which he has read of corpora lutea in virgins, and since he wrote[u] we have been furnished with abundant instances of their appearance in virgins not only of our own kind but of quadrupeds. Sir Everard Home[x] asserts that the corpus luteum is not a formation that fills up the cavity of a ruptured vesicle, but a substance in which the ovum is produced, and consequently no proof of conception. However this may be, the case remains the same; for he has repeatedly seen ovaria of both human and quadruped virgins that had discharged ova. Indeed he revives the old opinion of Kerckring,[y]—that ova grow

---

when most other people can see but little, set about looking for something wonderful, and discovered what nobody had ever seen before, viz. semen in the uterus and Fallopian tubes."

[t] In the body of a young woman, eighteen years of age, who had been brought up in a convent and had every appearance of being a virgin, Valisneri found five or six vesicles protruding in one ovarium, and the corresponding Fallopian tube redder and longer than usual, as he had frequently observed in brutes during heat. Bonnet gives the history of a young lady who died furiously in love with a man of low rank, and whose ovaria were turgid with vesicles of great size. Blancaard, Schurig, Brendelius, Santorini, and Drelincourt, mention analogous facts. Haller's notes to Boerhaave's *Prælect. Acad.*

[u] *Spec. Physiol.* &c. anno 1788. quoted in 562. (note [i].)

[x] *Phil. Trans.* 1819.

[y] *Anthrop. Ichnogr.* l. 3. and 12. quoted by Schurig. "Tam conjugatæ quam virgines hæc ova sæpissime excernunt, insensibiliter quidem, quia non advertunt, nec quicquam de iis suspicantur."

to maturity in succession and are discharged without copulation. On this point I find it difficult in the present state of our knowledge to make up my mind; but I think it pretty evident that, although the semen has no share in bursting the ovarium, the high excitement of copulation contributes very considerably to it, since the inferior degree of excitement which occurs during the heat of brutes and in the lascivious states of the human virgin is sufficient frequently to effect the discharge of ova. It is perhaps impossible otherwise to explain the fact that ova are so commonly expelled from the ovaria, and impregnated whenever a connection is arbitrarily or casually brought about. Hen pigeons, if kept with males, lay not only at an earlier age, but all the year round, instead of merely in the spring.

How the semen operates upon the ovarian secretion in fecundating and in transmitting the paternal peculiarities, is a mystery impenetrably concealed from human curiosity.

4. The rupture of the ovarium has been said not to occur till some time subsequent to coition.

Dr. Haighton saw the ovaria of rabbits bursting at the end of forty-eight hours, but never found any thing of regular form before the sixth day. Mr. Cruikshank says that he saw no ova in their tubes earlier than about the beginning of the third day.

(B) An instance of superfœtation of the description granted by Blumenbach occurred to the late Mr. Blackaller of Weybridge. A white woman of very loose character left her husband, and some time afterwards returned pregnant to her parish, and was delivered in the workhouse of twins, "one of which," says Mr. Blackaller, in an account which he sent me, "was born of a darker colour than I have usually observed the infants of negroes in the West Indies; the hair quite black, with the woolly appearance usual to them, with nose flat and lips thick:" the second child had all the common appearances of white children. Another is recorded by Dr. Dewees.[z] The mother was a servant in Montgomery County, and, on the report that she was pregnant, a black and a white man both ran away from the estate. Her mistress was present at the birth of the *black and the white twins*, and they were afterwards often seen by Dr. Dewees. One occurred at Rouen in 1806, in which there was a *white and mulatto* child, and

[z] Cox's *Philadelphia Medical Museum*, vol. i. The case usually quoted also occurred in America (South Carolina), and may be found in Buffon.

the woman, the *chère amie* of a white, confessed, on close examination, that she had twice yielded to the embraces of a negro when she supposed herself four or five months advanced in pregnancy.[a] The case of a married negress, who one morning admitted a white to her arms as soon as her black husband had risen, and produced a *black* and a *mulatto*, is recorded by Dr. Moseley as having occurred within his own time at Jamaica.[b] The most recent was recorded in 1821, by M. de Bouillon, a negress brought forth a *negro and a mulatto* child, and confessed having received the embraces of a white and a negro the same evening.[c]

We may, therefore, agree with Pliny,[d] who asserts that "Ubi paululum temporis inter duos conceptus intercessit, utrumque perficitur:" and believe his account of a girl in Proconnesus who produced twins, one resembling her master, the other the bailiff, having favoured both on the same day; no less than the other case of the same kind to which he alludes, and that there was some foundation for the story of Hercules and Iphicles.

The uterus has been sometimes wanting,[e] sometimes destitute of anterior opening,[f] and sometimes double,[g] in which last case some imagine superfœtation possible at any period after the first conception, provided each uterus have a distinct orifice. It has been removed after inversion, and when diseased, and lives have of late been saved by this operation.[h]

A dissection is described by Dr. Granville[i] of a woman who had borne eleven children, male and female, and who died soon after being delivered of twins of both sexes. The right half only of the uterus was found developed, the left extending scarcely half an inch from the centre and shaped to a perfectly straight line:

[a] *Annales de Montpellier*, quoted in the *Journal de Médecine*, t. xii.

[b] *Tropical Diseases*, p. 111.

[c] *Bulletin de la Faculté de Médecine*, 1821.

[d] *Hist. Nat.* vii. 9.

[e] Lieutaud, Sandifort, Morgagni, Stein, Theden, Schmucker, Engel.

[f] Louis.

[g] *Ephemerid. Natur. Curios.* Dec. 3. Ann. 7 and 8. Obs. 35. Cent. 9. Obs. 75. *Phil. Trans.* vol. iv. 1699. &c. &c.

Med. Facts and Observations, vol. iii. translated from the German.

[h] *v. c.* Newnham, *Inversio Uteri.* Davis, *ibid.* T. Windsor, *Med. Chir. Trans.* vol. x. &c. &c.

[i] *Phil. Trans.* 1818.

the left tube and ovary did not exist. This proves, if the proof were required, that one ovary is, like one testis, sufficient, not only for procreation, but for the procreation of offspring of both sexes. The writer thinks the case useful in proving also both that twins and twins of different sexes may come from the same ovary, contrary to the opinion of all physiologists, he says, except Sir Everard Home. The not very uncommon fact, however, of three or more children being produced at a birth, has always proved the former circumstance, and the opinion, not held by Sir Everard Home, was relinquished a century ago.[k]

As each fœtus, where there are more than one, may possess a separate placenta and chorion, and may come into the world solitarily, at some months distance perhaps from the other delivery, we see how easily practitioners may fancy a superfœtation, when there is simply an expulsion of twins, triplets, &c. at different periods. Still, I think, there can be no doubt of many cases of the simultaneous birth of children apparently of different periods, and of the birth of children apparently of the same period at intervals of a few months.[l]

(C) Mr. Bauer says he has detected the human ovum on the eighth day from coition: that it consisted of two membranes:— the external open throughout its length, but with its edges turned inwards, like shells of the genus voluta; the internal pointed at one end and obtuse at the other, slightly contracted in the middle, and containing, besides a slimy fluid, two globules that might be moved by pressure, but quickly resumed their situations, and were probably the rudiments of the heart and brain.[m]

(D) During fifty-seven years, above 78,000 women were delivered at the Dublin Lying-in-Hospital, and the proportion of women producing twins or more was about 1 in 57.

The proportion of males to females, about 10 to 9.[n]

[k] The doctrine of each ovarium furnishing a different sex, is indeed found in Hippocrates, Aristotle, Galen, Lactantius — a superstitious father of the church, Rhases, and Avicenna, but has been so long exploded, that Dr. Parsons, in his *Enquiry into the Nature of Hermaphrodites*, p. 43., written above eighty years since, declares it "cannot but seem obsolete before even a capacity of the lowest class."

[l] See examples by Dr. Maton, *Trans. of Coll. of Physicians*, vol. v. Foderé, *Méd. Légale*, t. i.; and by Dr. Dewees, *Philad. Med. Mus.* vol. i.

[m] *Phil. Trans.* 1817.

[n] John Cross, *Sketches of the Medical Schools of Paris*, p. 192.

According to Dr. Hufeland the numbers in Germany are as 21 to 20, born from 1811 to 1820 inclusively. The number of males exceeded that of females every year, and in the whole was 1,664,557, that of the females 1,590,510.[o]

According to the registers of the lying-in-hospital of Paris, during twenty years, 37,441 deliveries occurred; in 36,922 of which was only one child; in 444, two; and in 5 three. No greater number occurred, nor even for forty years before, in the whole of which sixty years were 108,000 deliveries. Of 54 twin deliveries, taken at random from the list, 15 were of a boy and girl; 13 were of girls; and 26 were of boys,—nearly half of the whole number.[p]

Four children are sometimes produced, and even five; but this is the highest number known, except in the case of the wax matron, who, for a judgment, once lay in of as many as there are days in the year.

There is a notion among the vulgar that if twins are of different sexes they cannot breed. This I know to be erroneous.

Some women produce more than one child at a birth repeatedly, and Gottlob mentions one who blessed her husband with eleven children at three births.

(E) Fourcroy is almost the only author who has examined the blood of the fœtus,[q] and his observations, Berzelius remarks, " seem to have been made by chance, and not to be deduced from any experiment;" " credible authors have asserted that the eye cannot distinguish between the arterial and venous blood of the fœtus."[r] Bichat could observe no difference in the arterial and venous blood of the umbilical chords of several guinea-pigs examined while the mother's respiration was still continuing, after an opening had been made into the abdomen, "—les deux sangs offroient une noirceur egale."[s] So too in regard to dogs.[t]

Yet Dr. Jeffrey,[u] Dr. Chapman,[x] and Dr. Bostock[y] have seen the arterial and venous blood differing in colour, and the latter declares

[o] *Edin. Phil. Journal*, vol. iii. p. 296. sq.

[p] *Edinb. Journal of Med. Science*, Jan. 1827. p. 366. sq.

[q] *Annales de Chimie*, t. vii. p. 162.

[r] *Animal Chemistry*. Translation, p. 41. sq.

[s] *Recherches Physiologiques*, p. 271.

[t] *Anatomie Générale*, t. ii. 344.

[u] *De Placenta*.

[x] Drs. Chapman and Rousseau, *Philadel. Journ. of the Medical and Physical Sciences*, No. 1. p. 182.

[y] *Elements of Physiology*, vol. ii. p. 199.

the difference to be so obvious that he "feels surprised" at the opinions of Bichat and Berzelius.

The changes in the blood can, however, be dispensed with by the fœtus much longer than by the adult. For respiration may be deferred a considerable time after birth (as formerly mentioned, p. 129.), circulation continuing even although the placenta has been expelled, especially if the temperature is maintained by a warm-bath. When respiration has commenced, its continuance is less dispensable, but for some time more so than subsequently.

In regard to the vascular connection between the mother and child, Prevost and Dumas ascertained that the blood of the fœtal and adult goat totally differ in regard to the red particles, — that these are much larger (as large again) in the fœtus, just as Hewson observed to be the case in the viper and chicken; see supra p. 20.

So fine is the connection between the mother and fœtus, that madder, while it dyes the former, does not appear in the latter.[z] But prussiate of potass given to the mother is said to be detected in the fœtus.[a]

The chick, nevertheless, in the egg, cut off from all intercourse with the mother, requires its blood to be purified by the external air: for if the shell is varnished, the chick dies; and if, during the latter half of incubation, the shell is carefully opened, the chorion, to use the language of Blumenbach, presents one of the most splendid spectacles in the organic creation; the arteries are seen carrying blood of a bright scarlet, and the veins of a livid red.[b] The fœtus of the kangaroo has no vascular connection with the mother, being surrounded by a kind of jelly, and is supplied with external air by tubes opening into the uterus from without for this express purpose.

In the wonderful world of insects, generation depends much, in some instances, upon national circumstances. In a hive of bees, for example, but one female has her sexual organs developed and breeds; the others of her sex labour only, unless she die, when the hive feed up another with a richer sort of honey which brings out the organs, and she becomes the new queen and breeds. A smaller number of the hive are males, and do no work, but are

[z] Dr. Chapman, l. c.

[a] *Edinb. Med. and Surg. Journal*, vol. v.

[b] *Comparative Anatomy.* Translated by Mr. Lawrence, § 375.

destined solely to impregnate the queen, and her successors in case of her death. And this, indeed, is a serious business. The queen, a few days after her birth, takes an airing, in which she is sure to meet with one of her swains, and he generally leaves his organs in her and dies of his laceration in half an hour. Happily, however, this single embrace impregnates all the eggs for two years (though she lays about 1500 a month all the year round) or perhaps for life.

SECT. XL.

OF THE NISUS FORMATIVUS.

583. Having simply described the phenomena of conception, and the changes which constant observation proves to occur both in the human ovum and the contained fœtus during pregnancy, we now proceed to those powers by which it appears that the stupendous process of generation is effected.

584. Even in our memory some physiologists of reputation have contented themselves with roundly asserting that true generation never occurs, but that the whole human race preexisted in the genitals of our first parents, in the shape of previously-formed germs which become evolved in succession. Some of these imagined the germs to be the spermatic animalcules of the male;[a] others imagined them to exist in the ovaries of the mother.[b]

585. This hypothesis of the successive evolution of germs

[a] See W. Fr. v. Gleichen, l. c.

[b] *v. c.* The illustrious Haller, who plainly asserted, *that all the viscera and even the bones of the future fœtus, nearly fluid indeed and therefore invisible, were pre-formed, before conception, in the maternal germ.*

In support of this hypothesis, he argued chiefly from the continuity of the membranes and blood-vessels between the incubated chick and the yolk of the egg. *Opera Minora.* t. ii. p. 418. sq.

But the more frequently I have demonstrated the phenomena of incubation in the physiological class, the less strength have I found in this argument.

Nor can I sufficiently wonder how this great physiologist could so constantly reject, as almost absurd, the inosculation, properly so called, of the vessels of the chick with those of the yolk, while at the same time he admitted and defended a perfectly similar inosculation in the connection of the human ovum with the gravid uterus!

See his *Elem. Physiol.* Lausannæ, 1788. t. viii. P. i. p. 94. comparing p. 257.

pre-formed from the creation, must, if carefully examined, be rejected.[c]

Not only is the superfluous and useless creation, which is supposed, of innumerable germs never arriving at evolution, repugnant to reason, but so many preternatural conditions[d] and such a multiplication of natural powers[e] are assumed, that it is perfectly irreconcileable with sound physiology.

Add to this, that, of the phenomena adduced in its favour, no one is sufficiently consonant with truth to establish the hypothesis.[f]

On the other hand, we have indubitable observations which refute it directly and completely.

586. The less this hypothesis of evolution, as it is commonly termed, is found consonant with fact and the rules of philosophising, the more strongly does the opposite opinion recommend itself to our notice by its simplicity and correspondence with nature, supposing as it does, not an evolution of fictitious germina by conception, but a true generation and gradual formation of a new conception from the hitherto formless genital matter.

587. This true generation by successive formation has been variously described by physiologists, but the following we consider as the true account.

1. The *matter* of which organised bodies, and therefore the human frame, are composed, differs from all other matter in this, — that it only is subject to the influence of the vital powers.[g]

2. Among the orders of vital powers, one is eminently remarkable and the least disputable of all, which, while it acts

[c] See L. P. *Zweifel gegen die Entwickelungstheorie. — Aus der Französischen Handschrift von* G. Forster. Gotting. 1788. 8vo.

[d] *v.* Kant's remarks on these, *Critik der Urtheilskraft,* p. 372.

[e] This defect I have shown at large, *Handbuch der Naturgeschichte,* p. 14. sq. 10th edit.

[f] Those who desire a fuller demonstration of this and other assertions but briefly noticed in the present section, I refer to the work, *über den Bildungstrieb.* 3d edit. Gotting. 1791. 8vo.

[g] See Chr. Girtanner, *über das Kantische Prinzip für die Naturgeschichte.* Götting. 1796. 8vo. p. 14. sq.

upon that matter, hitherto shapeless but mature, imparts to it a *form* regular and definite, although varying according to the particular nature of the matter.

To *distinguish* this vital power from the rest, permit us to designate it — NISUS FORMATIVUS.

3. The nisus formativus occurs to the genital *matter*, when this is mature and committed to the uterus in a proper condition and under proper circumstances, produces in it the rudiments of conception, and gradually *forms* organs fitted for particular purposes; preserves this structure during life, by nourishing (455, sq.) the body; and reproduces, (459) as far as it can, any part accidentally mutilated.[h]

588. We therefore think it very probable that those fluids which, during a successful coition, are thrown into the cavity of the uterus (527, 533, 551), require a certain period for becoming intimately mixed, acted upon, and matured; that, after this preparatory stage, the nisus formativus is excited in them, vivifying and shaping the hitherto shapeless spermatic matter partly into the beautiful containing ovum (565) and partly into the contained embryo; (569) and that this is the reason of our inability, notwithstanding the present perfection of optical instruments, to discover, during the first days after conception, any thing more than shapeless fluids in the womb, without the faintest trace of

[h] Here allow me to make three remarks.

1. I have used the expression — nisus formativus, merely to *distinguish* it from the other orders of vital powers, and by no means to explain the *cause* of generation, that I consider equally involved in Cimmerian darkness as the cause of gravitation or attraction, which are merely terms given to effects known, like the nisus formativus, à posteriori.

2. The word NISUS I have adopted chiefly to express an energy truly vital, and therefore to distinguish it as clearly as possible from powers merely mechanical, by which some physiologists formerly endeavoured to explain generation.

3. On the contrary, the point upon which the whole of this doctrine respecting the nisus formativus turns, and which is alone sufficient to distinguish it from the vis plastica of the ancients or the vis essentialis of C. Fr. Wolff and similar hypotheses, is *the union and intimate co-exertion of two distinct principles in the evolution of the nature of organised bodies, — of the* PHYSICO-MECHANICAL *with the purely* TELEOLOGICAL,—principles which have hitherto been adopted but separately by physiologists in framing theories of generation.

the form of an embryo, which, however, about the second or third week, suddenly as it were, become observable.

589. We should exceed the limits of these institutions, were we to adduce many of the arguments which may be drawn from facts, to illustrate, as in our opinion they most clearly do, the influence of the nisus formativus in generation. We will, however, venture to mention, as briefly as possible, a few, whose weight will, on a little close reflection, be sufficiently evident.

590. Such, in the history of *hybrid* animals, is the singular experiment of impregnating those which are *prolific*, for many generations, with male semen of the same species, by means of which the form of the young hybrids becomes so progressively different from the original maternal configuration, as to approach more and more to that of the father, till, by a kind of arbitrary metamorphosis, it is absolutely converted into it.[i]

591. Such, in our knowledge of *monsters* (which, according to the hypothesis of evolution, are nearly all maintained to have pre-existed in the germs from the first creation), is the well-known fact — that among certain *domestic* species of animals, and especially among sows, monstrosities are very common, whereas in the original wild variety they are extremely uncommon.

592. While the phenomena of *reproduction* are all much more explicable by the nisus formativus than by the pre-existence of germs for every part, some particular instances (*v. c.* that of the nails, which, after the loss of the first phalanx of the fingers, have been known to be reproduced on the neighbouring middle phalanx,[k]) admit evidently of no other solution. (A)

[i] Jos. G. Kölreuter, *Dritte Forsetzung der vorläuf. Nachr.* p. 51. sq.

[k] Recent instances of this remarkable phenomenon are related by Corvisart, *Journal de Méd.* March, 1809.

N. Ansiaux, *Clinique Chirurgicale.* Lyons, 1816. 8vo. p. 217.

London Medical and Physical Journal. July, 1816.

Another example I owe to my friend F. Sig. Voigt, professor at Jena.

But the most remarkable case I myself saw in a young medical man, attending

593. From an impartial view of each side of the question, it will clearly appear, that the defenders of the germs must allow to the male semen, not only an *exciting* power, as they do, but likewise great *formative* powers, and thus their doctrine stands in need of the assistance of the nisus formativus; while our explanation, on the contrary, is sufficient, without the aid of pre-existing germs, to explain the phenomena of generation. There can, consequently, be no reason for multiplying the *entia*, as they are called, unnecessarily. (B)

NOTES.

(A) See other examples in Note (B) Sect. XXXI.

The cut part of half a potatoe has been seen covered with little tubercles, similar to those on the convex surface, and from which fresh potatoes originate. See Keratry, *Inductions Physiolog. et Morales.*

(B) As in speaking of peculiar properties of any organ, Blumenbach designates them *vitæ propriæ*, without any explanation, intending merely the expression of the fact; so, in designating the power of the united genital male and female living fluids to change to an organised system, *nisus formativus*, he simply expresses the fact of the existence of this power.

Although in man, and all animals which have two sexes, two fluids co-operate, it would appear from the facts mentioned, p. 479, that the proportion of the female fluid is much the greater; and, indeed, there is no certainty that the male fluid combines with the female into a mass,—does more than influence it; as eggs are laid by birds without sexual intercourse, differing in no visible particular from those which are prolific; and the germ of many animals, also, particularly of the frog, is visible in the ovum before fecundation. The influence of the male, however, is much more

---

my lectures, who, when with the French army, lost the last joints of three fingers of the left hand, and two joints of the little finger, by frost, in the famous retreat to Beresina. The following year horny rudiments of nails were reproduced on the last phalanx but one of the fore, middle, and ring finger, but the little finger remained as before.

than to excite development, as the offspring more or less resembles the male, and often in the most minute points. The not uncommon occurrence of hair, teeth, and fat in the ovaria of virgins, would be an argument for the existence of the primordia in the female, were they not found also sometimes in other parts and in the testes of the male.

The supposition of the frame, if one may so speak, of the future animal being furnished by the female, does not imply its microscopic existence in her before the evolution of the ovaria, nor of all mankind in Eve. The embryo has the power of growing and of developing organs; the genital fluids, of changing to an embryo: but the power of developing organs does not imply their previous microscopic existence in the embryo, nor the power of changing to an embryo, the existence of an embryo. The fancy of the existence of all the human race, inclosed like pill-boxes — *emboîtement*, in our hapless general mother, is as unfounded in fact as it is preposterous.

Domestication has a great influence upon fecundity. The sow, cat, and pigeon are by no means so prolific in the wild state. The wild sow farrows but once a year, and has a litter never of more than ten: the domestic sow commonly twice a year, and perhaps each litter amounts to twenty-one.[l] How could this difference occur, Blumenbach asks, if the young were merely evolved from germs existing from the creation?

Indeed, in this strange hypothesis there must have been an uncommon store of germs prepared at the beginning, for the ovaria of a single sturgeon have contained 1,467,500 ova.[m]

The *nisus formativus* produces a being generally resembling the parents, but occasionally different. This subject will be fully treated of in the note on the varieties of mankind.

It is not probable that the ardour of the procreants affects the energy of the offspring. But from the days of Aristotle it has been remarked that bastards are frequently endowed with great genius and valour, and both ancient and modern history certainly affords many such examples; and the circumstance has been commonly ascribed to the impetuosity of the parents during

[l] Blumenbach, *Comparative Anatomy*, § 341.

[m] Petit, *Mém. de l'Acad. des Sciences*, 1733.

their embraces. Shakspeare, in King Lear, introduces Edmund bursting into this indignant soliloquy:—

> "Why bastard? wherefore base?
> When my dimensions are as well compact,
> My mind as generous, and my shape as true,
> As honest madam's issue? Why brand they us
> With base? with baseness? bastardy? base? base?
> Who in the lusty stealth of nature take
> More composition and fierce quality
> Than doth, within a dull, stale, tired bed
> Go to the creating a whole tribe of fops
> Got 'tween sleep and wake?" Act 1. Scene 2.

"Hercules, Romulus, Alexander (by Olympia's confession), Themistocles, Jugurtha, King Arthur, William the Conqueror, Homer, Demosthenes, P. Lumbard, P. Comestor, Bartholus, Adrian the fourth Pope, &c. were bastards; and in almost every kingdom the most ancient families have been at first princes' bastards; the worthiest captains, best wits, greatest scholars, bravest spirits in all our annals, have been base. Cardan, in his subtleties, gives a reason, &c. — Corpore sunt et animo fortiores spurii, plerumque ob amoris vehementiam, &c." [n]

Were this explanation satisfactory, the first fruits of wedded love would still generally be on an equality with illegitimate offspring. If a greater proportion of illegitimate than of legitimate persons have really rendered themselves illustrious, their superior energy may be attributed to the strength of their parents' constitutions, it not being likely that the weak and delicate so frequently become the prey of unlawful passions as the vigorous, and to the necessity in which such individuals usually find themselves to rely upon their own exertions. Their native excellence was at least not acknowledged by Moses. "A bastard shall not enter into the congregation of the Lord; even to his tenth generation shall he not enter into the congregation of the Lord." [o]

[n] Burton, *Anatomy of Melancholy*, vol. ii. p. 16. sq.

Vanini exclaims, "O utinam extra legitimum et connubialem thorum essem procreatus! Ita enim progenitores mei in venerem incaluissent ardentius, accumulatim affatimque generosa semina contulissent, e quibus ego formæ blanditiam et elegantiam, robustas corporis vires, mentemque innubilem, consequutus fuissem. At quia conjugatorum sum suboles, his orbatus sum bonis." *De Admirandis Naturæ.* Parisiis, 1616.

[o] *Deuteronomy*, xxiii. 2.

The vulgar are satisfied that mental impressions made upon the mother may affect the offspring. Credulous, as I may seem, I do confess that so many extraordinary coincidences, both in the human and the brute subject, have come to my knowledge, that I dare not affirm the common belief to be unfounded. That neither all nor most malformations can be thus explained, that pregnant women are frequently alarmed without such consequences, even when most dreaded, and that highly ridiculous resemblances are fancied to preceding longings and alarms which were forgotten or may be well suspected to have never existed, is incontestable. But, in other matters, when a circumstance may proceed from many causes, we do not universally reject any one because it is frequently alleged without reason. How those who believe the Divine authority of every part of their Bible can reconcile the success of Jacob's stratagem [p] (so anciently was the opinion common) with their contempt for the vulgar belief, they best can tell. [q]

A curious fact is recorded by the present Earl of Morton. His lordship bred from a male quagga and a mare of seven-eighths Arabian blood, a female hybrid, displaying in form and colour her mixed origin. The mare was given to Sir Gore Ouseley, who bred from her first a filly and then a colt, by a fine black Arabian horse; but both these in their colour and in the hair of their manes strongly resembled the quagga. The resemblance appears to have been rather less in the colt than in the filly. Dr. Wollaston soon afterwards learnt a similar fact in the case of a sow, which, after littering by a boar of the wild breed, was put,

[p] "And Jacob took him rods of green poplar, and of the hazel and chesnut tree; and pilled white strakes in them, and made the white appear which was in the rods. And he set the rods which he had pilled before the flocks in the gutters in the watering troughs, when the flocks came to drink, that they should conceive when they came to drink. And the flocks conceived before the rods, and brought forth cattle ringstraked, speckled, and spotted." *Genesis*, xxx.

[q] The paragraph above was published in the former edition, and since then Sir Everard Home also has supported the vulgar opinion and given some examples in the *Phil. Trans.* 1825. p.75. sqq. Indeed, he and Mr. Bauer think that they have even discovered nerves in the placenta, around the umbilical arteries, and in the maternal part of the placenta. A remarkable and most authentic case has just been published by Mr. Bennett, in the *Lond. Med. and Physic. Journal* for July last. A woman gave birth to a child with a large cluster of globular tumors growing from the tongue and preventing the closure of the mouth, in colour, shape, and size, exactly resembling our common grapes; and with a red ex-

long after the death of this, to a boar of a different breed, and produced pigs, some of which were marked like the first boar; and even in a second litter by a third boar, some slightly resembled the first.[r]

M. Girou Buzareingues mentions that a violent blow was given to a bitch while being lined; that she was paraplegic for some days, and when she produced her eight pups, all, excepting one, had the hind legs wanting, malformed, or weak.[s]

---

crescence from the chest as exactly resembling in figure and general appearance a turkey's wattles. On being questioned before the child was shown her, she answered, that while pregnant she had seen some grapes, longed intensely for them, and constantly thought of them, and once was attacked by a turkey-cock. Both growths were successfully removed, and Mr. Bennett has been kind enough to allow me to see them.

The circumstance of longing during pregnancy is rather curious. The stomach sympathises so strongly with the uterus, that many women experience nausea or even vomiting, chiefly in the morning, soon or immediately after conception, and perhaps during several of the first months: occasionally during the latter months only: some during the whole of pregnancy. Many long for certain nice articles of food, and become much distressed if not gratified; but others for coals, sealing-wax, flax, tar, chalk, raw meat, and live fish. Tulpius mentions a lady having devoured 1400 herrings in her pregnancy. But Ludovicus Vives tells us of a woman who longed for a bite in the back of a young man's neck, and would have miscarried if not gratified; and Langius, of another who had set her heart upon biting a baker's shoulder, which she saw bare and white as he carried his bread to the oven every morning. The husband bribed the baker at so much each bite. The poor fellow stood two very manfully, but when a third was talked of, his courage failed. A woman at Andernach on the Rhine longed for her husband, and is declared to have murdered him, ate what she could, and salted the rest. Shenkius, l. c. *de Gravidis.*

[r] *Phil. Trans.* 1821, P. 1.

[s] *Journal de Physiol.* t. vii.

SECT. XLI.

OF LABOUR AND ITS SEQUELÆ.

594. The fœtus, formed by the powers already described, and being now perfect and at the period of maturity, has to come into the world by means of *labour*.[a]

595. This critical *period* occurs naturally (and physiology treats solely of natural occurrences) at the end of the tenth lunar month from conception, i. e. about the 39th or 40th week. (A)

596. At that time, the pregnant woman is impelled to bring forth by an absolute necessity, less under the influence of the will than any other voluntary function (287).

597. Physiologists have differed in their explanations of the *causes* of so determinate and sudden an event. After all, the *exciting* cause of labour must be ascribed to an established law of nature, hitherto equally inexplicable with so many other *periodical* phenomena; *v. c.* the metamorphosis of insects, the stages of exanthematic fevers, crises, &c. &c., nor has the mature ovum been inaptly compared, *cæteris paribus*, to fruit, which, when ripe, falls almost spontaneously to the ground, from the constriction of those vessels which previously conveyed its nourishment. And in fact it has been remarked that the human placenta, at the approach of labour, is contracted, and, as it were, prepared for its separation from the uterus.

What is usually urged respecting the utmost expansion of the uterus, and other similar excitements to labour, is refuted by many circumstances, and, among the rest, by the numerous examples of extra-uterine, whether tubal or ovarian, concep-

[a] Fr. B. Osiander, *Handbuch der Entbindungskunst*, t. ii. P. i.

tions, in which, at the expiration of ten months from impregnation, the uterus, notwithstanding its vacuity, is seized with the customary, though indeed fruitless, pains. [b]

598. Besides this exciting cause, other very powerful *efficient* causes are requisite, as must be manifest from the relation of the ovum to the uterus.

We are persuaded that the *proximate* and primary cause, is solely the *vita propria* of the uterus. (42. 547) [c]

Among the *remote*, the most important appears to be the respiratory effort excited principally by the great connection [d] of the intercostal nerve with the rest of the nervous system.

599. We formerly noticed (582) that, in the latter periods of pregnancy, the uterus somewhat subsided, by which circumstance the form of the abdomen is a little changed and the inconveniences induced during advanced pregnancy in the function of respiration are relieved. At the same time, the vaginal mucus (543) is secreted more abundantly, the vagina itself is relaxed, the columns of rugæ are almost obliterated, and the labia pudendi swell; finally, near the approach of labour, the os uteri gradually dilates into a circular opening.

600. The *phenomena* of labour generally observe a regular order of commencement and progress, [e] whence accoucheurs have divided them into *stages*, of which the moderns enumerate four or five, although they define them variously.

601. In the *first*, the true pains occur, peculiar in their nature, proceeding from the loins in the direction of the lower parts of the uterus (recurring, at intervals, indeed, during the whole of labour, with various degrees of violence and frequency), mild in the beginning, at which time they are called *warning* and the os uteri begins evidently to dilate. The abdomen now falls still more, the urine is urgent, and abundance of mucus flows from the soft and tumid genitals.

[b] I have recorded a remarkable instance of this kind in the *Comment. Soc. Scient. Gottingens.* vol. viii.

[c] Gonsult J. De Gorter, *de actione viventium particulari,* p. 38.

[d] *v.* Camper, *Demonst. anat. pathol.* L. ii. p. 9.

[e] *v.* Smellie, *Set of anatomical tables,* tab. xi.—xv.

602. In the *second*, the pains, increasing, are called *preparing*, and, by the compressing effect of the respiratory organs, a strong inspiration, &c., a segment of the lower part of the membranes of the ovum is protruded through the uterine orifice into the vagina.

603. In the *third*, the pains, becoming more excruciating, are called *labour pains*, and act with still more violence upon the uterus, which is driven downwards and compressed against the fœtus, so that the protruded segment of membranes becomes extremely tense, is burst asunder, and the greater part of the liquor amnii escapes.

604. Finally, in the *fourth* and last stage, the pains, becoming dreadfully violent and *agitating*,[f] are accompanied by great exertions of the woman herself; almost always too by shivering, shrieking, tremor of the knees, &c. The head of the child, now on the verge of birth, penetrates, and the face first appears, the vertex usually remaining under the arch of the pubes and the rest of the head in the mean time being farther propelled, and revolving around the impacted vertex as around an axis. Thus the child comes into the world, in the midst of a red discharge, consisting of a second portion of the liquor amnii mixed with blood.

605. Soon after the expulsion of the child, *the delivery of the secundines* in the *fifth* stage commences, attended by a painful though much less violent exertion, and followed by another hemorrhage from that part of the cavity of the womb[g] to which the placenta had adhered by means of the decidua crassa.[h]

[f] Although, even among my own countrywomen, the symptoms described under these four stages vary greatly in violence and proportionate duration; nevertheless, however naturally they take place, they universally (excepting some extremely rare cases) so far surpass, even under the most favourable circumstances, the pains experienced by domestic brutes in their labours, that I trust no one who has frequently witnessed labours in both, will seriously doubt the immense difference between them in this respect.

[g] B. S. Albinus, *Tab. uteri gravidi,* vii.

Wm. Hunter, *Anat. of the gravid uterus.* tab. x. fig. 3.

[h] Nic. Massam and all since his time denominate this portion of the interior of the womb, during or shortly after pregnancy, *the cotyledons,* from the analogous

606. Immediately that both burthens are expelled, the uterus begins gradually to contract, until it acquires its original form and very nearly its original dimensions.

607. For about a week after labour, the *lochia* are discharged, for the most part very similar to the catamenia, but rather more copious, especially if the mother does not suckle her offspring. About the sixth day their red colour becomes fainter, and afterwards changes to white.

At the same time the uterus is liberated from the remaining shreds of the decidua, and, having thus completed the function of pregnancy, is again ready for menstruation or conception.

NOTE.

(A) It was formerly believed that pregnancy might be extended to twelve months and even two years. With all deductions for error and temptation, I think a few satisfactory modern cases are recorded of its protraction to one, two, and even eight weeks beyond the fortieth.[1]

---

appearance observable in the gravid uterus of sheep or goats, in which similar cavities (*acetabula*) exist, receiving what are called the glandular corpuscles of the chorion that correspond with the fœtal portion of the human placenta.

Whatever was hollow, like an acetabulum, was called κοτύλη by the ancients. Vide J. Cammerarii *Comm. utriusque linguæ*, p. 256. 384.

[1] See Dr. Smellie's *Treatise on the theory and practice of Midwifery*; Dr. Bartley's *Treatise on Forensic Medicine*, &c. Bristol. Foderé declares, that to his own certain knowledge his wife went ten months and a fortnight in her two first pregnancies. M. Dulignac, long a surgeon-major, declared on a trial, that in regard to his three last children his wife was pregnant thirteen months and two weeks with two, and eleven months with the other; and that he had discovered each of these pregnancies between the fourth and fifth months by the motion of the child and watched them all to their termination. Foderé, *Méd. Legale*, t. ii.

That there is great variety among brutes was known to the ancients, but M. Teissier has made very extensive observations on this point: — Of 160 cows, 14 calved from the end of the 8th month to 8 months and 26 days; 3 on the 270th day; 50 from the 270th to the 280th; 68 from the 280th to the 290th; 20 on the 300th; 5 on the 380th. He obtained similar results with 202 mares, 130 sows, and 139 rabbits. M. Darcet found that in the same hen's nest, 1 egg hatched on the 13th day; 2 on the 17th; 3 on the 18th; 5 on the 19th. (Foderé.)

SECT. XLII.

OF THE MILK.

608. The *breasts*, most sacred fountains, and, as Gellius Favorinus the philosopher elegantly calls them, the rearers (*educatores*) of the human race, are intimately connected with the uterus in various ways. The functions of neither can properly be said to exist during infancy; at puberty, both begin to flourish, — when the catamenia appear, the breasts assume some degree of plumpness; from that period they undergo either simultaneous changes, — the breasts beginning to swell and secrete milk during the pregnancy of the womb; or alternate changes, — the catamenia ceasing while the child is suckled, or the lochia becoming copious if the child is not suckled, and *s. p.* Finally, when age creeps on, the function of each absolutely ceases, — when the catamenia disappear, both the uterus and the breasts become equally inert. I omit pathological phenomena; *v. c.* those which occur in irregular menstruation, leucorrhœa, after extirpation of the ovaria, and in other morbid affections.

609. If this intimate connection is kept in view, we shall not be astonished that nearly every description of sympathy formerly mentioned (56) exists between these organs of the female thorax and abdomen.[a]

610. The influence of the anastomotic sympathy between the internal mammary and epigastric artery,[b] although formerly overrated,[c] is evinced by the change which the latter

[a] J. Anemaet, *De mirabili quæ mammas inter et uterum intercedit sympathia.* LB. 1784. 4to.

[b] Eustachius, tab. xxvii. fig. 12.

Haller, *Icon. anat.* fasc. vi. tab.i.

[c] As G. R. Boehmer properly remarks, *De consensu uteri cum mammis caussa actis dubia.* Lips. 1750. 4to.

experiences in its diameter during pregnancy and suckling. (A)

611. Both the uterus and mammæ appear to have a kind of affinity for the chyle, observable in many diseases, and nearly always in new-born children.

612. The *breast* of women, [d] belonging to the most characteristic marks of the human female both by its form during the flower of age and by the longer continuance of this form after the period of suckling than occurs in any other female animal, is composed of a placentiform series of conglomerate glands, divided by numerous furrows into larger lobes, and, as it were, buried in a mass of fat; the anterior part swells out particularly with a firmer description of fat over which the skin is exceedingly thin.

613. Each of these lobes is composed of still smaller lobes, and these of acini, as they are termed, to which the extreme radicles[e] of the *lactiferous ducts* adhere, deriving a chylous fluid from the ultimate twigs of the internal mammary arteries.

614. These radicles, gradually uniting,[f] form large trunks, corresponding in number with the lobes, — fifteen or more in each breast. These are every where dilated into large sinuses, but have no true anastomosis with each other.[g]

615. These trunks terminate in very delicate excretory canals, that are collected, towards the centre, by means of cellular substance, into the *nipple*,[h] which, supplied with extremely fine blood-vessels and nerves, is capable of a peculiar erection on the approach of certain external stimuli.

616. The nipple is surrounded by the *areola*,[i] which, as

[d] A. B. Kölpin, *De structura mammarum.* Griphisw. 1765. 4to.
Athan. Joannidis, *Physiologiæ mammarum muliebrium specimen.* Hal. 1801. 4to.

[e] *v.* C. A. Covolo's two plates at the end of Santorini's posthumous tables.

[f] *v.* Mich. Girardi, tab. i. annexed to the same plates of Santorini.

[g] J. Gottl. Walter, *Observ. Anat.* p. 33. sq.

[h] Santorini, tab. posth. viii.

[i] Ruysch, *Thes.* i. tab. iv. fig. 4.

well as the nipple, is remarkable for the colour[k] of the reticulum under the cuticle,[l] and contains sebaceous follicles.[m]

617. The secretion of the breast is the *milk*, well known in colour, watery, somewhat fatty, rather sweet, bland, resembling in all respects the milk of domestic animals, but subject to infinitely greater varieties in the proportion of its constituent parts, far more difficult of coagulation from the great quantity of essential salt, to be spoken of presently, which it contains, and affording no trace of volatile alkali.[n]

618. When coagulated by means of alcohol, it presents the same elements as the milk of other animals. Besides the *aqueous* halitus which it gives off when fresh and warm, the *serum*, separating from the *caseous* part, contains sugar of milk[o] and acetic acid mixed with phosphate of lime and of magnesia, and with oil and mucus. The butyraceous *cream* is said to consist of globules of various and inconstant size, their diameter ranging between $\frac{1}{200}$ and $\frac{1}{600}$ of a line.[p] (B)

619. The analogy between chyle and blood, and between both these fluids and milk,[q] renders it probable that the milk is a kind of chyle reproduced, or rather again separated from the blood before its complete assimilation. This idea is

[k] In pregnant women, especially during the first pregnancy, the nipples are usually yellow.

In the Samojede females, even when virgins, Klingstaedt asserts that they are quite black. *Mém. sur les Samojedes et les Lappons*, p. 44.

[l] B. S. Albinus, *Annotat. Acad.* L iii. tab. iv. fig. 3.

[m] Morgagni, *Advers. Anat.* i. tab. iv. fig. 2.

[n] Fl. J. Voltelen (Præs. Hahn), *De lacte humano observationes chemicæ.* LB. 1775. 4to.

Parmentier and Deyeux, *Précis d'Expériences et observations sur les différentes espèces du lait.* Strasburg, 1798. 8vo.

Thenard, *Annales de Chimie*, t. lix. p. 262.

[o] Marc. L. Williamoz, *De sale lactis essentiali.* LB. 1756. 4to.

[p] Senac. *Tr. du cœur*, vol.ii. p.276. ed.2.

Fr. v. P. Gruithuisen, *Untersuch. über den Unterschied zwischen Eiter und Schleim durch das Microscop.* Munich. 1809. 4to. p. 16. fig. 15.

[q] Consult J. Theod. Van de Kasteele, Diss. *de analogia inter lac et sanguinem.* LB. 1780. 4to.

And Alex. Wilson on the analogy between milk and chyle, *Observations relative to the influence of the climate*, p. 97. sqq.

strengthened by the frequent existence in the milk of the particular qualities of food previously taken, [r] and by the chylous appearance of the watery milk secreted during pregnancy and immediately after labour. [s]

620. The reason why this bland nourishment of the fœtus becomes more thick and rich by continued suckling, is probably the abundance of lymphatics in the breasts. Those vessels continually absorb more of the serous part of the milk, in proportion as its secretion is more copious and of longer standing, and, by again pouring this part into the mass of blood, promote the secretion (477): after weaning they take up the remaining milk and mix it with the blood.

621. The milk is secreted in greatest quantity immediately after delivery; and, if the infant sucks, amounts to one or two pounds every twenty-four hours, until the menses, which usually cease during suckling, (556) return.

Occasionally virgins, and new-born infants of either sex, nay even men, [t] as well as the adult males of other mammalia, [u] have been known to furnish milk.

622. The abundance of milk excites its *excretion*, and even causes it to flow spontaneously: but pressure, or the suction of the child, completes its discharge. (D)

[r] *v.* Among a host of witnesses, Kölpin in Pallas's *Neuen nordischen Beyträgen*, vol. ii. p. 343.

[s] Many circumstances induce me to believe that the lymph of the absorbents is of much importance in the secretion of milk.

For instance, the swelling of the subaxillary glands almost always observable during the first months of pregnancy.

But especially the remarkable fact, — that, in advanced pregnancy, when, from the womb compressing by its size the large and numerous lumbar plexuses of lymphatics, the legs have swollen, this œdematous tumour so completely disappears immediately after labour that the calves of the legs almost hang flaccid from the lymph finding no impediment in the lumbar plexuses and rushing upwards, and a copious secretion of milk instantly ensues upon the passage of the lymph.

The momentary thirst (330) experienced on applying the child to the breast, from the absorption of fluid in the fauces, may be also mentioned.

[t] This is asserted to be common in Russia. *Comment. Acad. sc. Petropolit.* vol. iii. p. 278. sq. (C)

[u] I have spoken of this at large in the *Hannoverisch. Magazin*, 1787, p. 753. sqq.

NOTES.

(A) Women, it is said, have had three, four, and even five breasts: in triangular arrangement; one under another on one side, or on both sides; all in a line; the supernumerary ones on the back; or, in the case where there were five, one under another on each side, and the fifth below all, and in the centre, five inches above the navel. [x]

A woman lives at present at Marseilles, with a third perfect breast, four inches below the great trochanter of the left thigh. This gave milk like the other two, and though she never had but one child she continued a wet-nurse for six years. Her own child sucked this femoral breast for three and thirty months, putting his little head under his mother's petticoats and standing or kneeling during the business. This woman's mother had also a third breast, but it was placed on the left side of the chest, and was sucked in common with the others by seven children. [y]

I am not acquainted with the dissection of any such cases, but if it is not probable that in the latter, a direct anastomosis exists between the uterine vessels and those of this breast, the influence of the arterial communication in ordinary cases may appear still further improbable.

The case reminds me of a monstrosity in the same situation as this,—the thigh of a boy, aged fourteen; seen by Zacchias's friend, Balthassar Bonannus, "vir humanitate et doctrina insignis." [z] But instead of a breast, there was a female pudendum, labia, hair, and rima: on separating the labia, no opening appeared.

(B) The lower portion of cows' milk which had stood some days was found by Berzelius [a] to have a specific gravity of 1.033, and to contain

Water - - - - -	928.75
Cheese with a trace of butter - -	28.00
Sugar of milk - - -	35.00
Muriate of potash - - -	1.70
Phosphate of potash - -	0.25

[x] *Dictionnaire des Sciences Médic.* Art. Cas rares.

[y] Magendie's *Journal de Physiologie*, Janvier, 1827.

[z] *Quæst. Med. Legales*, p. 503.

[a] *Medico-Chirurgical Transactions*, vol. iii.

Lactic acid, acetate of potash, with a trace of lactate of iron - -	6.00
Earthy phosphates - - -	0.30
	1000.00

The supernatant cream contained:

Butter - - - - -	4.5
Cheese - - - -	3.5
Whey - - - - -	92.0
	100.0

We have seen the analogy between vegetables and animals in structure and function, as well as in elementary and proximate principles. The secretions of both may be innocuous or deleterious. The most remarkable analogy in secretion respects milk. In South America, Humboldt saw a tree that, if wounded, yields abundance of rich milk, which the negroes drink and grow fat upon, and which affords a caseous coagulum. The tree grows on the barren rock; has coriaceous dry leaves; for several months is not moistened by a shower, and its branches appear dry and dead: yet, if an incision is made in its trunk, the milk pours forth. This " sweet vegetable fountain" is most copious at sun-rise, and the blacks and natives are then seen hastening from all quarters with bowls to the *cow-tree*.

(C) Mr. Wentzel met with an old Chipewyan, who, on losing his wife in child-birth, had put the infant to his breast and earnestly prayed that milk might flow, and had actually been happy enough to see sufficient produced to enable him to rear the child. The Indian was now old, but the left breast still retained the unusual size acquired by nursing. [b]

A parallel instance is recorded by a Bishop of Cork. His lordship had given half-a-crown to a poor Frenchman above seventy years of age, who made the best return he could by showing his lordship what he knew must be a curiosity,—two very large breasts, with nipples larger than the bishop had ever seen in a woman; and related that, his wife dying when his child was two months old, he endeavoured to pacify it at night by putting it to his

[b] Capt. Franklin's *Narrative of a Journey to the Polar Sea*, p. 157. sq.

breast, and at length milk actually came, so that he suckled and brought it up.[c]

A lamb, belonging to Sir William Lowther, having lost its mother, sucked a wether "and brought him to milk and was maintained by him all the summer: he had two considerable teats on his udder, each side whereof was about the bigness of a hen's egg," and the milk was made to spurt to a distance of two yards a month after the lamb was weaned.[d]

Blumenbach has described a he-goat which it was necessary to milk every other day for a year;[e] so that, to say with Virgil, *mulgeat hircos*, is not tantamount to calling a man a fool.

A bull which had been put to cows successfully, but had also female organs, though the vagina was apparently too small to have ever admitted the male organ, gave milk, according to satisfactory testimony.[f]

I myself saw two married women with milk in their breasts, one of whom had never been pregnant, but always menstruated regularly, and said this had been the case for nine months; the other had not been pregnant for upwards of six years, had weaned her child, and at the end of seven months miscarried, and said she had immediately afterwards observed the milk, which had been secreted for six months, and was increasing at the time I saw her.

I also attended a young single lady, whom I believe never to have been pregnant, but who was subject to amenorrhœa, and had then not menstruated for five months, and laboured, apparently, under ovarian disease: milk oozed very copiously from her breasts, and the medical attendant informed me that the left had secreted it for many months.[g]

(D) It may be worth while here to take a general view of the subject of generation.

[c] *Phil. Trans.* vol. xli. p.813.

[d] *Phil. Trans.* No. 214. p.263.

[e] *Hannoverisch. Magazin*, 1787, p. 753. *Comparat. Anat.* § 364.

[f] *Phil. Trans.* 1799, p. 171. sq. See supra, p. 419. n. [t].

[g] In the *Phil. Trans.* abridged, vol. ix. p. 206. sq. is an instance seen by Dr. Stack, in Tottenham Court Road, of an old woman of sixty-four, who had not borne a child for sixteen years, secreting milk after repeatedly applying her grandchild to her breasts for the purpose of quieting it, and continuing to furnish milk in great abundance up to the time of the narration, — four years, to the children of her daughter, who, finding her mother so useful, "was emboldened to bid fair for an increase of issue, which till then, she knew not how to nourish or provide for."

[h] See Cuvier *Leçons d'Anatomie comparée*, t.v. Generation.

Life never occurs spontaneously in matter, but is always propagated from an organised system already endowed with it. Such at least, appears to be the inevitable conclusion from the facts within our observation. No instance has been known of a plant or animal of any species, whose mode of multiplication may be always easily examined, springing up spontaneously ; and although in many other cases the origin often cannot be discovered, yet surely our inability to discover the mode of propagation does not justify us in denying the existence of it ; but, the general analogy, the discovery of the modes in which many species propagate which were formerly adduced as instances of spontaneous generation ; the generation of oviparous or viviparous animals, actually observable in some species, whose existence in this particular residence is inexplicable (as certain *entzoa* found in the cellular texture),[i] and the occasionally manifest source of the difficulties which obstruct our enquiries, lead necessarily to the belief, not of the unreality of the fact, but of our deficient penetration. I will recur to this subject in the last note to Sect. XLIV.

The simplest mode of increase is by the detachment and independent existence of a portion of a system. In this way trees, [k] polypes, some worms, and many animalcules,[l] multiply.

[i] Cuvier *Règne Animal,* t. iv. p. 2. In the disease of wheat, called the purple, Mr. Bauer has discovered innumerable animalcules in the seed. Their presence appeared inexplicable, yet he found them multiply by viviparous generation. But the difficulty was solved by placing a quantity of them in the depression at the back of a healthy seed, and sowing this ; when he found the stem of the new plant filled with them. *Phil. Trans.* 1823. Some animalcules are endowed with so small a sense of delicacy, that three individuals co-operate at procreation. Sennebier's Introduction to his translation of Spallanzani's *Opusc. di fisica animale e vegetabile,* &c. p. lxxvi.

[k] Hic plantas tenero abscidens de corpore matrum
Deposuit sulcis ; hic stirpes obruit arvo,
Quadrifidasque sudes et acuto robore vallos ;
Silvarumque aliæ pressos propaginis arcus
Exspectant, et viva sua plantaria terra ;
Nîl radicis egent aliæ : summumque putator
Haud dubitat terræ referens mandare cacumen.
Quin et caudicibus sectis (mirabile dictu)
Truditur e sicco radix oleagina ligno.

Virgil. *Georgica.* Lib. ii.

[l] See Spallanzani's admirable *Observations et expériences sur les Animalcules.* He found a small portion detach itself from the bodies of some, the bodies of others split longitudinally, of others transversely, of others both longitudinally and transversely into four parts, and the new animalcules soon acquired the size of the parent and experienced the same changes in their turn.

Next comes the formation of the rudiments of a perfectly new being by the system of another. Thus we have the seed of vegetables, the ova and fœtus of animals. This occurs by means of two matters, which in some examples are furnished by the same, and in others, by different, systems. The vegetable kingdom affords innumerable instances of the former, the acephalous mollusca and the echinus are examples in the animal kingdom. [m] Both the vegetable and animal kingdoms abound in instances of the latter. Here again there are three varieties. The fluid of the male may be applied to the ova of the female after they are discharged from her body, as in some fish of the bony kind and in cephalopodous mollusca; while being discharged, as in the frog and toad; or it may be conveyed to the female system, and this, either without the contact of the male, as in those vegetables not hermaphrodite, where the wind, insects, &c. convey it, or by means of copulation, as in the mammalia, [n] birds, most reptiles, and some fish, hermaphrodite gasteropodous mollusca, crustacea,

[m] It is singular that some hermaphrodites do not impregnate themselves, but mutually impregnate and are impregnated by others; such are the gasteropodous mollusca and many worms.

[n] The fair sex were formerly treated with more politeness than at present. An accidental pregnancy was frequently attributed to the warmth of imagination, the influence of demons, and many other circumstances supposed equally powerful as the deed of kind. In Venette's *Tableau de l'Amour conjugal*, and in Bartholin's works, may be seen an *Arrêt Notable de la Cour du Parlement de Grenoble*, which, upon the attestation of many *matrones* and *sages femmes* and *docteurs* of the University of Montpellier *et autres personnes de qualité*, that women often fall pregnant spontaneously, declares a lady who had brought forth a son although her husband had been absent four years, to be a woman of worth and honour, and the child to be the legitimate heir of Monsieur the husband. When a demon bore the blame, he was called an *incubus*, and his semen always struck so cold to the ladies "*ut displicentiam magis quam delectationem inde sint consecutæ.*" Zacchias, *Quæstiones Medicæ Legales*, lib. vii. tit. 1. Quæst. vii. 7. A demon that played the part of a female, was named a *succubus*. It was asserted that a mischievous devil would often act as a *succubus*, and then, metamorphosing himself into an *incubus*, deposit in the vagina of some woman the semen which he had received from a man.

See also Varro, *De re rust.* ii. 1. Columella, vi. 27. and Pliny, *Hist. Nat.* viii. 17.

The ancients believed that mares were sometimes impregnated by the wind,—ἐξανεμȣ̃σθαι.

Vere magis, quia vere calor redit ossibus, illæ
Ore omnes versæ in Zephyrum stant rupibus altis,

and insects. In the mammalia, one copulation is sufficient for only one conception; among poultry its effects are so extensive, that a hen will lay a long succession of fruitful eggs after one intercourse with the cock; in the aphis and some monoculi, it is sufficient for the impregnation of eight, twelve, or fifteen generations.

The ovum after its fecundation may be nourished by a fluid enclosed within the same case, and is then hatched out of the body by the common temperature, as in insects, or by that of the parent, as in birds, or hatched within the body of the mother, as in serpents; or it may be nourished by a substance shed around it in the womb, as in the kangaroo, or by means of an attachment of some of its vessels to the maternal system, as in the mammalia in general: — some animals being thus oviparous, others ovoviviparous, and others viviparous.

The mode of nourishment after birth is various. Some are able, without any peculiar arrangement, immediately to support themselves; for the wisdom of the Creator ordains the delivery of each species of animals at that season of the year when every thing is in the most favourable state for administering to the necessities of the offspring. Some, many insects for example, are born in the midst of food, the parent having instinctively deposited the egg in nutrient matter either found in mass or carefully collected by her.[o] Others have food collected daily by the parents. Some, as all the dove kind, are fed by a substance secreted from the crops of both parents;[p] others by a fluid secreted by peculiar

---

Exceptantque levis auras; et sæpe sine ullis
Conjugiis vento gravidæ (mirabile dictu)
Saxa per et scopulos et depressas convallis
Diffugiunt.

VIRGIL, *Georg.* Lib. iii.

[o] Some insects,— ichneumons, lay their eggs in living caterpillars or other species of their own genus, which are consequently destroyed, so that certain species appear to naturalists created solely for the destruction of others. The most frightful example is the female of a species of sphex; she digs a hole in sandy ground, drags a large spider or caterpillar into the hole, bites off its legs to prevent its escape, and deposits an egg in the hole, so that the young one may nourish itself with the spinning fluid of the poor animal. Blumenbach, *Handbuch des naturgeschichte.*

[p] Hunter, *On a secretion in the crops of breeding pigeons for the nourishment of their young,* in his *Observations on certain parts,* &c. p. 235.

glands belonging to the female only.[q] The instinct which leads the parent carefully to tend the offspring, ceases at the period when the system of the offspring is sufficiently advanced to supply its own exigencies, and the parent does not breed again till this is the case.

---

[q] Mr. Hunter satisfied himself experimentally of the truth of the common assertion, — that the she-ass gives milk no longer than the impression of the foal is upon her mind. The skin of her foal thrown over the back of another, and frequently brought near her, is sufficient. *Journal of the Royal Institution,* No. 2.

SECT. XLIII.

OF THE DIFFERENCES IN THE SYSTEM BEFORE AND AFTER BIRTH.[a]

623. From what has been said relatively to the functions of the fœtus still contained within its mother, and immersed as it were in a warm bath, there must evidently be a considerable difference between its functions and those of the child that is born and capable of exerting its will. The chief points of difference we will distinctly enumerate.

624. To begin with the blood and its motion, this fluid is remarkable both for being of a darker red, incapable of becoming florid on the contact of atmospheric air, and for coagulating less readily and perfectly than after birth.[b] Its course, too, is very different in the fœtus whose circulation is connected with the placenta and who has never breathed, from its course after the cessation of this connection with the mother and after respiration has taken place.[c]

[a] On the subject of this section consult, among numerous others, Trew, *De differ. quibusdam inter hominem natum et nascendum intercedentibus.* Norimb. 1736. 4to.

Andr. and Fr. Roesslein (brothers), *De differentiis inter fœtum et adultum.* Ibid. 1783. 4to.

Ferd. G. Danz, *Zergliederungskunde des ungebohrnen Kindes mit Anmerk.* von. S. Th. Soemmerring. Frankfort. 1792. 2 vols. 8vo.

Also Theod. Hoogeveen, *De fœtus humani morbis.* LB. 1784. 8vo. p. 28. sq.

Fr. Aug. Walter, *Annotat. Academ.* already quoted, p. 44. sq.

And J. Dan Herholdt, *De vita imprimis fœtus humani.* Havn. 1802. 8vo. p. 61. sq.

[b] Fourcroy, *Annales de Chimie,* t. vii. p. 162. sq.

[c] Consult Herm. Bernard, *De eo quo differt circuitus sanguinis fœtus ab illo hominis nati.* Reprinted in Overkamp's collection, t. i.

Jos. Wenc. Czikanek, *De actuosa hominis nascituri vita s. circulat. fœtus ab hominis nati diversitate.* Reprinted in Wasserberg's collection, t. iv.

625. First, the umbilical vein, coming from the placenta and penetrating the ring called umbilical, runs to the liver, and pours its blood into the sinus of the vena portæ, the branches of which remarkable vein distribute one portion through the liver, while the *ductus venosus* ARANTII [d] conveys the rest directly to the inferior vena cava.

Both canals, — the end of the umbilical vein contained in the abdomen of the fœtus and the venous duct, become closed after the division of the chord, and the former is converted into the round ligament of the liver.

626. The blood arriving at the right side of the heart from the inferior cava, is in a great measure prevented from passing through the lungs, and is derived into the left or posterior auricle of the heart, by means of the Eustachian valve, and the foramen ovale.

627. For, in the fœtus, over the opening of the inferior cava, there is extended a remarkable lunated *valve*, [e] termed, from its discoverer, [f] Eustachian, which usually disappears as adolescence proceeds, but, in the fœtus, appears to direct [g] the stream of blood coming from the abdomen towards an opening, immediately to be mentioned, existing in the septum of the auricles.

628. This opening is denominated the *foramen ovale*, [h] and is the cause that certainly the greatest part of the blood which streams from the inferior cava is poured into the left

---

Sabatier, at the end of his *Tr. Complèt d'Anat.* vol. iii. p. 386. sq. 1781.; and in the *Mémoires Mathemat. et Physiques de l'Institut.* t. iii. p. 337. sq.

But especially J. Fr. Lobstein, *Magazin Encyclopédique.* 1803. t. iii. vol. li. p. 28. sq.

[d] *v.* Arantius, *De humano fœtu libellus,* p. 97.

Compare B. S. Albinus, *Explicatio tabular. Eustachii,* p. 164. sq.

[e] Haller, *De valvula Eustachii.* Gotting. 1738. 4to.

[f] Eustachius, *De vena sine pari,* p. 289. Opuscula, tab. viii. fig. 6. tab. xvi. fig. 3.

[g] J. F. Lobstein, *De valvula Eustachii.* Arg. 1771. 4to.

[h] Haller, *De foramine ovali et Eustachii valvula.* Gotting. 1748. fol. c. f. ae. and much more copiously in his *Opera minora,* t. i. p. 33. sqq.

auricle[i] during the diastole of the auricles. A falciform valve, placed over the foramen, prevents its return, and appears likewise to preclude its course into the right auricle during the systole of the auricles. By means of this valve, the foramen generally becomes closed in the first years of infancy, in proportion as the corresponding Eustachian valve decreases, and more or less completely disappears.[k]

629. The blood which enters the right auricle and ventricle principally proceeds from the superior cava, and flows but in a very small quantity into the lungs, while, from the right ventricle, which, in the fœtus, is particularly thick and strong for this purpose, it pursues its course directly to the arch of the aorta, by means of the *ductus arteriosus*,[l] which is in a manner the chief branch of the pulmonary artery. A few weeks after birth, this duct becomes obstructed and converted into a kind of dense ligament.

630. The blood of the aorta, being destined to return, in a great measure, to the mother, enters the *umbilical arteries* (572), which pass out on each side of the urachus at the umbilical opening, and after birth, likewise become imperforate chords.[m]

631. As the function of the *lungs* scarcely exists in the fœtus, their appearance is extremely different from what it is after the commencement of respiration. They are proportionally much smaller, their colour is darker, their substance denser, consequently their specific gravity is greater, so that while recent and sound they sink in water, whereas, after birth, they, cæteris paribus, swim upon its surface.[n] The

[i] For an account of the opinion of C. Fr. Wolff, who regards the foramen ovale as another mouth of the inferior cava, opening into the left auricle in the same manner as the mouth commonly known opens into the right, see *Nov. Comment. Acad. Scient. Petropol.* t. xx. 1775.

[k] H. Palm. Leveling, *De valvula Eustachii et foramine ovali.* Anglipol. 1780. 8vo. c. f. ae.

[l] B. S. Albinus, *Annot. Acad.* l. ii. tab. vii. fig. 7.

[m] v. Haller, *Icones Anat.* fasc. iv. tab. iii. vi.

[n] Here is not the proper place for explaining the conditions under which this occurs, and the cautions therefore requisite in giving an opinion, in a court of

right lung has the peculiarity of dilating during the first inspiration rather sooner than the left.[o] (A) The other circumstances attending the commencement of respiration were mentioned in the section upon that function.

632. From our remarks upon the nutrition of the fœtus, it is clear that its alimentary tube and chylo-poietic system must be peculiar. Thus, *v. c.* in an embryo a few months old, the *large intestines* very nearly resemble the small; but, during the latter half of pregnancy, being turgid with meconium, they really deserve the epithet by which they are commonly distinguished.

633. The *meconium* is a saburra, of a brownish-green colour, formed evidently from the secreted fluids of the fœtus, and chiefly from its bile, because it is first observed at the period corresponding to the first secretion of the bile, and, in monstrous cases, where the liver has been absent, no meconium, but merely a small quantity of colourless mucous, has been found in the intestines.

634. The *cæcum* is extremely different in the new-born child from its future form, and continued straight from the appendix vermiformis, &c.[p]

635. Other similar differences we have already spoken of, and shall now pass over.

Such are the *urachus*, (573)

The *membrana pupillaris*, (262)

And the *descent of the testes* in the male. (510 sq.)

Some will be treated of more properly in the next section. Others, of little moment, we shall entirely omit.

---

justice, founded on the *examination* of the *lungs*. Among many other writings, the very important posthumous paper of Wm. Hunter may be consulted in the *Medical Observ. and Enquiries,* vol. vi. p. 284. sq.

Ph. Corn. Heinecken's dissertation, *De docimasia pulmonum incerto vitæ et mortis recens natorum signo*. Gott. 1811. 4to.

And Fr. B. Osiander, *Comment. de respiratione, vagitu et vi vitali fœtus humani inter partum,* &c., on which compare the *Götting. Gel. Anz.* 1820. p. 1955. sq.

[o] Portal, *Mém. de l'Acad. des Sc. de Paris.* 1769. p. 555. sq.

Metzger, *De pulmone dextro ante sinistrum respirante.* Regiom. 1783. 4to.

[p] B. S. Albinus, *Annotat. Acad.* l. vi. tab. ii. fig. 7.

636. This is a favourable opportunity for briefly noticing some remarkable parts which are out of all proportion larger in the fœtus, and appear to serve important purposes in its economy, although their true and principal design deserves still further investigation.

They are usually styled glands, but their parenchyma is very different from true glandular structure, nor has any vestige of an excretory duct been hitherto discovered in them. They are the thyreoid, the thymus, and the supra-renal glands. [q]

637. The *thyreoid gland* [r] is fixed upon the cartilage of the same name belonging to the larynx, has two lobes, is, as it were, lunated, [s] and full not only of blood, in which it abounds in the fœtus, but of lymphatic fluid, and becomes, as age advances, gradually less juicy. [t]

638. The *thymus* is a white and very delicate structure, likewise bilobular, sometimes completely divided into two parts, occasionally containing a remarkable cavity, [u] placed under the superior part of the middle of the sternum, always ascending as far as the neck on each side, [x] of extremely great proportionate size in the fœtus, abounding in a milky fluid,

[q] F. Meckel, *Abhandlungen aus der menschlichen und vergleichenden Anatomie.* Halle, 1806. 8vo. He makes it probable that these three organs contribute to the chemical functions of the nervous and hepatic systems, and thus diminish the quantity of hydrogen and carbon.

[r] C. Uttini, *De glandulæ thyroideæ usu,* in the *Comment. instituti Bononiens,* vol. vii. p. 15. sq.

[s] Haller, *Icones Anat.* fasc. iii. tab. 3.

[t] J. Ant. Schmidtmüller, *über die Ausführungsgänge der Schilddrüse.* Landut, 1804. 8vo.

[u] Aug. Louis de Hugo, *De glandulis in genere et speciatim de thymo.* Gotting. 1746. 4to. fig. 2.

Morand the younger, *Mémoires de l'Acad. des Sc. de Paris.* 1759. tab. 22—24.

Vincent Malacarne, *Memorie della Societa Italiana,* t. viii. 1799. P. i. p. 239. sq.

Flor. Caldani, *Congettura sopra l'uso della glandula timo.* Venice. 1808. 4to.

Sam. Chr. Lucae, *Anatomische Untersuchungen der Thymus.* Fasc. i. ii. Frankfort on the Maine. 1811. 4to.

C. Fr. Th. Krause, *Opinionum de thymi functione examen.* Gott. 1818. 8vo.

[x] Haller, *Icones Anat.* l. c.

becoming gradually absorbed in youth, and frequently disappearing altogether in old age.[y]

639. The *supra-renal glands,* called also renes succenturiati and capsulæ atrabiliariæ, lie under the diaphragm on the upper margin of the kidneys,[z] from which, in the adult, they are rather more distant, being proportionally smaller. They are full of a dark fluid of a more reddish hue in the fœtus than in the adult. (B)

NOTES.

(A) Now that the importance of auscultation in examining diseases of the chest is generally allowed, this point has been investigated by the ear; and we are informed that the respiratory murmur immediately after birth is heard equally in both lungs.[a]

(B) Blumenbach has omitted to notice in this section one of the most striking peculiarities of the fœtus,—the very great proportionate bulk of its liver. The prodigious size of this organ arises from the distribution of four-fifths of the blood of the umbilical vein through it, and probably, in a certain degree, as some think, from the great quantity of meconium in its biliary ducts. After birth, no blood is conveyed by the umbilical vein, and the expansion of the thorax readily expresses the abundance of meconium; hence the liver must diminish.

This peculiarity, as well as the great size of the thyreoid, thymus, and supra-renal glands, probably serves some purpose hitherto undiscovered, unless the liver have the same excrementory office as the lungs, and therefore at this period does the work of both; but an evident good effect results from it in relation to the organs of the thorax. In the fœtus the lungs are completely devoid of air, and consequently there cannot be much, if any, circulation of blood through the pulmonary artery and veins,

[y] Hewson, *Experimental Enquiries,* P. iii. passim.

[z] See Eustachius their discoverer, tab. i. ii. iii., and tab. xii. fig. 1. 10. 12. Haller, *Icones Anat.* fasc. iii. tab. vi. Malacarne, l. c.

[a] Mr. Jowitt in Dr. James Johnson's *Med. Chir. Review.*

and the liver by its magnitude, protruding the diaphragm upwards, renders the capacity of the chest correspondently small, and at the same time it contains an immense proportion of blood. After birth, the diminished size of the liver allows a great increase to the capacity of the chest; not only is full inspiration allowed, and consequently a free passage to the blood of the pulmonary vessels during inspiration, as Haller remarks,[b] but a certain degree of permanent dilatation of the lungs is allowed (for much air remains in the lungs after every expiration), and since the liver contains, immediately after birth, so much smaller a portion of the blood of the system than before, the greatly increased supply required by the lungs is thus afforded.[c] See Note D. Sect. VIII.

[b] *Elementa Physiologiæ*, t. viii.

[c] See Mr. Bryce, *Edinb. Med. and Surg. Journal*. 1815. Jan.

SECT. XLIV.

OF THE GROWTH, STATIONARY CONDITION, AND DECREASE OF THE HUMAN SYSTEM.

640. Nothing more remains than to survey at one view the natural course of the life of man, whose animal functions we have hitherto arranged in classes and examined individually, and to accompany him through his principal epochs from his birth to his grave. [a]

641. The *commencement of formation* appears to take place about the third week from conception (569), and genuine *blood* is first observable about the fourth, the life of the fœtus at this period being extremely faint (82) and little more than that of a vegetable; the *motion of the heart* (98) has, under fortunate circumstances, been observable at this time in the human embryo, [b] and even commonly been denominated the *punctum saliens*, from the days of Aristotle, who observed it in the incubated egg. [c]

The original form of the embryo is simple, and, as it were, disguised, wonderfully different from the perfect conformation of the human frame, which deserves to be regarded as the grandest effect of the nisus formativus, and at which it arrives by gradual changes, or, if we may so speak, metamorphoses, from a more simple to a more perfect form. [d] (A)

[a] Vide Const. Anast. Philites, *De decremento seu de marasmo senili.* Hal. 1808. 8vo.

[b] Vide J. de Muralto, *Ephemerides N. C.* Dec. ii. ann. 1. p. 305.

Roume de St. Laurent, in Rozier's *Obs. et Mém. s. la Physique.* Juillet. 1775. p. 53.

[c] Aristotle, *Hist. Animal.* l. vi. c. 3. Opera, vol. ii. p. 326.

[d] Hence, as I have remarked in another place, (*Nova Litteraria Goettingensia,* a. 1808. p. 1386.) human monsters are not unfrequently met with so strongly resembling the form of brutes; because the nisus formativus, having been dis-

642. The *formation of human bone* [e] begins, if I am not deceived, after the seventh or eighth week. First of all, the osseous fluid forms its nuclei in the clavicles, ribs, vertebræ, the large cylindrical bones of the extremities, the lower jaw, and some other bones of the face, in the delicate reticulum of some flat bones of the skull, — of the frontal and occipital, but less early in the parietal. [f]

In general, the growth of the embryo, and indeed of the human being universally both before and after birth, is more rapid as the age is less, and *vice versa*.

643. About the middle of pregnancy, certain fluids begin to be secreted, as the *fat* (486) and *bile*. In the course of the seventh month, all the organs of the vital, natural, and animal functions have made such progress, that, if the child

---

turbed and obstructed from some cause or other, could not reach the highest pitch of the human form, but rested at a lower point and produced a bestial shape. On the contrary, I have never once found among brutes a true example of monstrosity, which, by a bound of the nisus formativus, bore any analogy to the human figure.

For fuller information in regard to the resemblance of the very early human embryo at first to the larvæ of reptiles, and afterwards in some measure to the fœtuses of quadruped mammalia, consult, after Harvey, *De generat. animal.* p. 184. 235. sq. London. 1651. 4to. Grew, *Cosmol. Sacr.* p. 37. 47. Lister, *De humoribus.* p. 444. and others, especially Autenreith, *Observat. ad histor. embryon. facientium,* P. i. Tubing. 1797. 4to. Fr. Meckel, both *Auffätz. zur menschl. u. vergleich. anat.* p. 277. sq. and *Beyträg. zur vergleich. anat.* p. 63, and elsewhere. And Const. Anast. Philites, l. c.

[e] I say of *human* bone; for in the incubated chick it commences much later, — at the beginning of the *ninth* day, which corresponds with the *seventeenth week* of human pregnancy.

Observations, therefore, made on the incubated chick, must not be hastily applied to the formation of the human embryo, — an error committed by the great Haller himself, who asserted decidedly that *what he had demonstrated in regard to the incubated chick, was equally applicable to other classes of animals, and to man himself.*

This prejudice subsequently gained so much ground, that some physicians, who endeavoured to settle the forensic disputes respecting premature labour, deduced their arguments from this hasty comparison of the periods of incubation with those of human pregnancy. Vide *v. c.* Hug. Marreti, *Consultation au sujet d'un enfant, &c.* Dijon. 1768. 4to.

[f] I have treated of this at large in my osteological work, P. i. S. ii. and iii.

happens to be born at this period, it is called, in a common acceptation of the word, *vital*, and regarded as a member of society.

644. In the fœtus, near its full growth, not only is the skin covered by a caseous matter, but delicate *hair appears upon the head*, and *little nails* become visible ; the *membrana pupillaris* splits (262); the cartilaginous external ear becomes more firm and elastic; and in the male the *testes* descend. (510 sq.) (B)

645. About the end of the tenth lunar month, the *child*, being born (595), undergoes, besides those important changes of nearly its whole economy that were formerly described at large, other alterations in its *external appearance ; v. c.* the down which covered its face at birth gradually disappears, the wrinkles are obliterated, the anus becomes concealed between the swelling nates, &c. (C)

646. By degrees the infant learns to employ its *mental faculties* of perception, attention, reminiscence, inclination, &c. whence, even in the early months, it dreams, and *s. p.* [g]

647. The organs of the *external senses* are gradually evolved and perfected, as the external ear, the internal nares, the covering of the eyes, *viz.* the supra-orbital arches, the eyebrows, &c.

648. The bones of the skull unite more firmly; the *fonticuli* are by degrees filled up; and, about eight months after birth, *dentition* commences.

649. At this period the child is ready to be *weaned*, its teeth being intended to masticate solid food and not to injure the mother's breast.

650. About the end of the first year, it learns to rest upon its feet and *stand erect*, — the highest characteristic of the human body. [h]

651. The child, now weaned from its mother's breast and

[g] Consult Tiedemann, *uber die Entwickelung der Seelenfähigkeiten bey Kindern*, in the *Hessisch. Beytr.* Vol. ii. P. ii. iii.

[h] Jer. Vrolik (præs. Brugmans), *Diss. de homine ad statum gressumque erectum per corporis fabricam disposito.* Lugd. Bat. 1795. 8vo.

capable of using its feet, improves and acquires more voluntary power daily: another grand privilege of the human race is bestowed upon it — the use of *speech*, — the mind beginning to pronounce, by means of the tongue, the ideas with which it is familiar.

652. The twenty milk teeth by degrees drop out about the seventh year, and a *second dentition* produces, in the course of years, thirty-two permanent teeth.

653. During infancy, *memory* is more vigorous than the other faculties of the mind, and much more powerful than at any other period in tenaciously receiving the impressions of objects: after the fifteenth year, the fire of *imagination* burns more strongly.

654. This more lively state of the imagination occurs very opportunely at *puberty*, when the body, undergoing various remarkable changes, is gradually prepared for the exercise of the sexual functions.

655. Immediately after the period when the breasts of the adolescent girl have begun to swell, the chin of the boy is covered with down, and other phenomena of approaching puberty manifest themselves in either sex. The girl begins to *menstruate* (554), — an important change in the female economy, accompanied, among other circumstances, nearly always, by an increased brightness of the eyes and redness of the lips, and by more evident sensible qualities of the perspiration. The boy begins to secrete genuine *semen* (527), and, at the same time, the *beard*[1] grows more abundantly, and the *voice* becomes extremely grave.

By the spontaneous internal voice of nature, as it were, the *sexual instinct* (71) is now for the first time excited, and man, being in the flower of his age, is capable of sexual connection.

[1] The fabulous report that prevails even to this day, respecting the want of beard among some American nations, I refuted by a host of witnesses in the *Götting. Magaz.* ann. ii. P. vi. p. 418. sq.

Add, from later writers respecting the North American Indians, J. Heckewelder, *von den Indianischen Völkerschaften*, p. 340. sq. and respecting the Brazilians, Prince Maximilian, *Reise*, vol. i. p. 135. and elsewhere.

656. The *period* of puberty cannot be exactly defined: it varies with climate and temperament,[k] but is generally more early in the female; so that, in our climate, girls arrive at puberty about the fifteenth year, and young men, on the contrary, about the twentieth. (D)

657. Soon after this, *growth* terminates; at various periods in different climates, to say nothing of varieties in individuals and families.[l].(E)

658. The *epiphyses* of the bones, hitherto distinct from their diaphyses, now become intimately united, and, in a manner, confounded with them.

659. At *manhood* — the longer and more excellent period of human existence, life is, with respect to the corporeal functions, at the highest pitch (82), or, in other words, these functions are performed with the greatest *vigour* and *constancy;* in regard to the mental functions, the grand prerogative of mature *judgment* is now afforded.

660. The approach of *old age*[m] is announced in women by the cessation of the catamenia (556), and not unfrequently by an appearance of beard upon the chin;[n] in men, by less

[k] I have inserted in the *Bibl. Medic.* vol. i. p. 558. sq. an account communicated to me by G. E. ab Haller, of procreation in a Swiss girl only nine years of age.

[l] For man has no peculiar privilege of not experiencing the effects of climate in common with other organised bodies, which are commonly known to arrive at their growth much later, *cæteris paribus,* in cold than in warm climates.

As to the giants of Patagonia and the dwarfs of Madagascar, mentioned by Commerson, I have reduced the exaggerated accounts of the former to a true statement, and shown that the latter are diseased Cretins, in my Treatise *De gen. hum. var. nativ.* p. 253. 260. ed. 3.

[m] J. Bern. Fischer, *Tract. de senio ejusque morbis.* Ed. 2. Erf. 1760. 8vo.

Benj. Rush, *Medical Inquiries and Observations,* vol. ii. Philadel. 1793. 8vo. p. 295. sq.

Burc. W. Seiler, *Anatomiæ c. h. senilis specimen.* Erlang. 1799. 8vo.

Const. Anast. Philites, l. c.

[n] Vide J. Bürlin, *De fœminis ex suppressione mensium barbatis.* Altorf. 1664. 4to.

This remarkable phenomenon, that deserves further investigation, is analogous to a change frequently remarked in female birds, which, after ceasing to lay eggs, lose the feathers peculiar to their sex and acquire those characteristic of the male. I have treated of this at large in my commentary *de nisus formativi aberrationibus.* Gotting. 1813. 4to. p. 8. (F) alacrity to copulate: in both, by a senile[o] *dryness* and a gradually manifested *decrease* of vital energy.

661. Lastly, the frigid condition of *old age* is accompanied by an increasing dulness of both the external and internal senses, a necessity for longer sleep, and a torpor of all the functions of the system. The hairs grow white and partly fall off. The teeth gradually drop out. The neck is no longer able to give due support to the head, nor the legs to the body. Even the bones themselves — the props of the machine, in a manner waste away, &c.[p]

662. Thus we are conducted to the boundary of physiology, — *to death without disease*,[q] — to the senile εὐθανασία, which it is the first and last object of medicine to procure, and the *causes* of which must be self-evident from our preceding account of the animal economy.[r]

663. The *phenomena* of a moribund person[s] are coldness of the extremities, loss of brilliancy in the eyes, smallness and slowness of the pulse, which more and more frequently intermits, and infrequency of respiration, which at length terminates for ever by a deep expiration.

In the dissection of other moribund mammalia the struggle of the heart may be perceived, and the right auricle and ventricle are found to live rather longer than the left.(117)

664. Death is manifested by the coldness and rigidity of the body, the flaccidity of the cornea, the open state of the anus, the lividness of the back, the depression and flatness of

[o] Joach. H. Gernet, *De siccitatis senilis effectibus*. Lips. 1753. 4to.

[p] I do not here repeat what I have said at large in my osteological work, p. 36. sq. upon the remarkable wasting of the bones of old men.

[q] G. Gottl. Richter, *De morte sine morbo*. Gotting. 1736. 4to.

[r] J. Oosterdyk Schacht, *Tr. qua senile fatum inevitabili necessitate ex hum. corp. mechanismo sequi demonstratur*. Ultraj. 1729. 4to.

Matt. Van Genus, *De morte corporea et causis moriendi*. LB. 1761. 4to. reprinted in Sandifort's *Thesaurus*. vol. iii.

C. G. Ontyd, *De morte et varia moriendi ratione*. Lugd. Bat. 1791. 8vo.

Curt. Sprengel, *Instit. Medic.* t. i. Amst. 1809. 8vo. page 289. sq.

[s] See the successive progress of the phenomena of death observed by the individual himself, a man of middle age, dying of dysentery, in Moritz's *Magaz. zur Erfahrungs-Seelen-Kunde*, vol. i. P. i. page 63. sq.

the loins (59 *note*), and, above all, by an odour truly cadaverous.[t] If these *collective marks* are present, there can scarcely be room for the complaint of Pliny,—that we ought not to feel assured of the fate of a man though we see him lie dead.[u] (G)

665. It is scarcely possible to define the natural *period* of life, or as it may be termed, the more frequent and regular limit of advanced old age.[x] But, by an accurate examination of numerous bills of mortality, I have ascertained a remarkable fact—that a pretty large proportion of Europeans reach their *eighty-fourth* year, while, on the contrary, few exceed it. (H)

666. But, on the whole, notwithstanding the weakness of children, the intemperance of adults, the violence of diseases, the fatality of accidents, and many other circumstances, prevent more than about perhaps seventy-eight persons out of a thousand from dying of old age, without disease; nevertheless, if *human longevity*[y] be compared, *cæteris paribus*, with the duration of the life of any other known animal among the mammalia, we shall find that, of all the unreasonable complaints about the misery of human life, no one is more unfounded than that which we commonly hear respecting the shortness of its duration. (I)

[t] Durondeau, *Nouveaux Mém. de l'Ac. de Bruxelles*, vol. i. 1788. P. i.

[u] C. Himly, *Commentatio* (which gained the royal prize) *mortis historiam, causas et signa sistens*. Gotting. 1794. 4to.

Sal. Anschel, *Thanatologia s. in mortis naturam, causas, genera, species, et diagnosin disquisitiones*, ib. 1795, 8vo.

[x] Among other well-known treatises on this subject, consult J. Gesner, *De termino vitæ*. Tigur. 1748. 4to. reprinted in the *Excerptum Italicæ et Helveiicæ litterat.* 1759. t. iv.

[y] Bacon de Verulamio, *Historia vitæ et mortis*. Opera. vol. ii. p. 121. sq. 128. sq. London. 1740. fol.

Chr. W. Hufeland, *Makrobiotik*, t. i. page 90. and elsewhere. edit. 3. 1805.

NOTES.

(A) Some animals undergo extraordinary metamorphoses after birth. An insect is, on first leaving its egg-shell, a maggot (*larva*); then it becomes a grub (*nymphæ* or *pupæ*, &c.); and lastly a fly (*imago*). The frog is at first a tadpole, has no extremities, but, like a fish, tails and gills. Dr. Edwards has proved that, by excluding tadpoles from the light, they will grow to double or triple the size that tadpoles usually attain, but are not metamorphosed to frogs. He thinks that the proteus anguinus, which, like tadpoles, has lungs and gills, is but the first stage of an animal which is prevented from becoming perfect by inhabiting the subterraneous waters of Carniola. He concludes, therefore, that light has a great influence upon the human body; and ascribes the observation of Humboldt, that among millions of Caribs, Mexicans, Peruvians, &c, not one instance of deformity appeared, to the exposure of their bodies to light, and much of the sickliness of imprisoned persons and scrofulous children living in close streets, to the want of light.[z]

The influence of food upon the changes of animals is great. Aphidivorous flies are larvæ for eight or ten days, pupæ for about a fortnight, and perfect insects about nearly as long; in the whole not living more than six weeks. But a pupa deprived of food underwent no change, and lived a pupa for twelve months.[a]

(B) Dr. Edwards discovered that brutes which are born with their eyes closed, or cannot at first walk about and procure food, or have not integuments sufficiently copious to preserve their temperature, are little warmer than the surrounding medium if removed from their nest or bed: but that they acquire about the fifteenth day, if quadrupeds, and about the end of the third or fourth week, if birds, the calorific power of adults. In all these the ductus arteriosus is generally large and open, and closes as the calorific powers increase. Upon its state, and not upon the circumstances first mentioned, does the temperature depend. As the calorific powers change rather suddenly, we must suppose the completion of the closure to be rapid.[b]

The human fœtus resembles these brutes in having the eye closed by the membrana pupillaris for many months, and children born before time long continue to require much artificial warmth. But although the temperature of the very young is so easily lowered, the ill effects of cold are better recovered from than by adults.

[z] *De l'Influence, &c.* P.iv. c. 15. [a] Kirby and Spence, vol. i. p.404.
[b] l. c. P. iii. ch. 1. p. 618.

Life also continues longer without respiration, or with a limited quantity of air, than in adults.[b]

These circumstances connect the cold and warm-blooded, and the hybernating and non-hybernating, animals.

(C) At full time,[c] boys, according to some,[d] weigh rather less than girls.

Chaussier states that at full time the navel is exactly central: that at eight months the centre is higher; at seven still higher; and at six, precisely at the lower part of the sternum.

Children born at the end of the sixth and even fifth month have lived.[e]

(D) Instances continually occur in both sexes of early puberty, sometimes joined with very rapid growth. The intellect however does not usually keep pace with the body, (or rather the parts of the brain destined for intellect, with the rest of the body)[f] nor are such individuals commonly long lived. Some males are reported to have been adult before the completion of their first year, an instance of which will presently be given in note E. One of the earliest examples of female puberty is related in the *Medico-Chirurgical Transactions:*[g] the girl began to menstruate when not

[b] Bohn mentions having seen two female infants alive who had been buried deep in the ground by their incontinent mothers, and not dug up for some hours. He says also that, in 1719, a female infant was dug up alive after being buried for some time at its birth by the mother; and that in 1764, a new-born child was taken alive from a heap of straw, in which it had been placed, wrapped in several cloths by its inhuman parents seven hours previously. Dr. James Curry has recorded a case upon the authority of a surgeon of the Northampton General Hospital, of a child which was born apparently dead, and, on account of the attention required by the mother, put aside, and then carried by a woman to a wash-house, in the depth of winter. After two hours the surgeon enquired after the child, and by perseverance recovered it. *Obs. on App. Death, &c.*

There can be no doubt that many infant lives are annually lost from the want of perseverance in resuscitating measures.

[c] Sir Richard Croft attended where the child weighed 15 pounds; and on the other hand the weight has sometimes not exceeded 3 pounds.

[d] *Phil. Trans.*

[e] Harvey, *Op.* p. 545. Mahon, *Méd. Lég.* i. 243. *Ed. Med. and Surg. Journ.* 1815. Belloc, *Cours de Méd. Légale*, 77. sq.

[f] In a recently described case of puberty, in a boy three years of age, the judgment, as usual, is not at all superior to that of other children, but the part of the head stated by Gall as the residence of the organ of sexual love, has been examined, and is so large that Dr. Spurzheim declares few adults have it of equal size. *Med. Chirurg. Trans.* vol. xi. The same in vol. xii. p. 76.

[g] Vol. iv.

three years of age, and soon after acquired large breasts, broad hips, &c. Schurig quotes numerous, and for the most part probably fabulous, instances of fecundity in either sex between the seventh and twelfth year, and one of a little couple, he nine and she eight, who managed to beget a child.[h]

The activity of the grand organs of generation, — the testes in the male and the ovaria in the female, is so connected with the great changes which occur in the rest of the generative organs and in the system at large at the period of puberty, that these changes are prevented if those organs are previously removed, and are in general proportional to their evolution and activity,[i] and when they have experienced no change at the age of puberty, some of the marks of the other sex, as large breasts in the male, may even occur; and, if their removal is practised after puberty is established, the system more or less relapses into its former condition or acquires more or less the characteristics of the opposite sex. This is well known in regard to brutes and the males of our species. Burckhardt, one of the latest travellers in Egypt, says that the face of those unfortunate creatures who are emasculated when boys appears "almost destitute of flesh, the eyes hollow, the cheek-bones prominent, and the whole physiognomy has a skeleton-like appearance:" and that the operation is usually performed between the eighth and twelfth year. Windhus, however, in his journey to Mesquinez met a troop of eunuchs belonging to the king, and says they were the fattest persons he ever saw. We have one instance of the castration of a woman: her ovaria protruded at the groins, and were so troublesome as to induce her to submit to their removal in St. Bartholomew's Hospital; she afterwards grew thinner and more muscular, her breasts shrunk away, and she ceased to menstruate.[k] When the ovaria have been found deficient, the signs of

[h] *Spermatol.* p. 185. sq.

[i] I say generally, because, for instance, the greatest evolution of the testes is often accompanied either by little beard, or a small larynx, or some analogous circumstance, while the other marks of manhood are strikingly manifested; and *vice versa*. A boy only six years of age, without any premature evolution of the organs of generation, is recorded to have had a beard. *Philos. Trans.*

[k] Pott, *Works*, vol. iii. p. 330. A castrator of sows and other brutes in Germany is said to have been so enraged with his daughter for giving loose reins to her passions, as to have resolved to extinguish them, and to have completely succeeded by removing her ovaria. — "Ita bilis mota est, ut, aperto latere, castraret puellam, quam ab eo tempore nulla tetigit veneris cupido.' Boerhaave, *Prælect. Acad.* t. vi. p. 127.

puberty had not appeared.[l] The absence of the uterus only is not attended by any deficiency in the general changes,[m] nor does its removal destroy desire or give a woman the characters of the male. Nay, where it only is absent there are monthly pains, and frequently most severe ones, in the pelvis, with all the attendant circumstances of menstruation, as if the discharge were taking place.[n]

As puberty sometimes occurs extraordinarily soon, so does it sometimes, though more rarely, extraordinarily late. Professor Wilson knew a young man whose penis and testes at twenty-six were no larger than in boys of eight; at this time, however, they began to evolve, he had erections and emissions, fell in love, and in two years, *viz.*, when twenty-eight, they were as large as in other men, and he married and became a father.[o] Dr. Gall remarks that precocity or tardiness may in the same way be the lot of any faculty and its organ. Gessner, one of the best and most amiable poets of Switzerland, was declared by his preceptors incapable of any attainment when ten years of age. One of the most celebrated physicians of Berlin could neither combine his ideas nor speak at thirteen.[p]

John Hunter made an experiment respecting the removal of one ovarium only. He took two young sows in all respects similar to each other, and, after removing an ovarium from one, admitted a boar of the same farrow to each, and allowed them to breed. The perfect sow bred till she was about eight years old, — a period of almost six years, in which time she had thirteen farrows, and in all one hundred and sixty-two pigs; the other bred till she was six years old, — during a space of more than four years, and in that time she had eight farrows and in all seventy-six pigs. Thus it would appear that each ovarium is destined to afford a certain number only of fœtuses, and that the removal of one, although it does not influence the number of fœtuses produced by the other, causes them to be produced in a shorter time.[q]

[l] *Phil. Trans.* vol. xcv.

[m] *Mémoires de la Société Médicale d'Emulation.* Paris, tom. ii.

[n] See a case read before the Medicinisch-Chirurgischte Gesellschaft, and to be found in the *Lond. Med. & Physic. Journal,* 1819, p. 512. sq. where another is quoted from Theden. I believe I know a living case of this kind myself, but dissection only can clear up the matter.

[o] *Lectures on the Male Urine and Genital Organs,* p. 424.

[p] l. c. t. i. p. 194. sq.

[q] *An experiment to determine the effect of extirpating one ovarium upon the number of young produced.* In his *Observations on certain parts,* &c.

The sexual organs are usually regarded as the cause of sexual desire. That this is not the case, may be shown by many circumstances. Desire is by no means commensurate with the size of the genitals: even when the genitals are precociously developed desire is sometimes not felt.[r] Desire is often felt after the removal of the testes, and in old age when the genitals are powerless. It must, therefore, depend upon some other part. This part appears to be the cerebellum. Desire is, *cæteris paribus*, naturally strong or weak in the adult, in proportion to the large or small size of the cerebellum, whether of the lobes or the fundamental portion called the vermiform process, which alone exists in birds, amphibia, fish, and insects;[s] whenever I have accurately known the strength of the sexual propensities in either sex, the size of the occiput has without a single exception corresponded. Before puberty the cerebellum is small; its proportion in size to the cerebrum is at birth from one-ninth to one-twentieth, or even less: in the adult it is as one-fifth, or at the least as one-seventh, and acquires its full development between the eighteenth and twenty-sixth years; and the breadth and prominence of the occiput are proportional. In old age, the cerebellum shrinks, and the internal table of the occipital bone following, bony matter is deposited between the two tables, and the bone at the fossæ occipitales becomes much less transparent. Gall possesses old crania in which the cerebellum had returned to the dimensions of infancy, and the occipital fossæ had become shallow. When the cerebellum is precociously developed, desire is felt by the child, even though the genitals are not above the ordinary size.[t] Inflammation and irritation of the cerebellum are found by

[r] A female infant who cut four teeth at the end of the first fortnight, walked and had hair reaching to the middle of her back soon after the seventh month, menstruated and had stiff brown hair on the pubes, and every corporeal mark of puberty at the ninth month, died in her twelfth year, without having shown the least sexual instinct. *Allgemeine Deutsche Leits. fur Gebactskunde.* Gall saw a similar case, and others may be found in Buffon. (Gall, l. c. p. 260.) Gall found the cerebellum had not grown proportionally, — "had but a very insignificant development."

[s] Gall, l. c. t. iii. p. 254.

[t] "At Paris," says Gall, (l. c. t. iii. p. 261.) "I saw the son of a mulatto, not quite three years of age; he threw himself not only upon little girls, but upon women, and urged them boldly and obstinately to gratify his desires. The sexual organs were not prematurely developed, but merely of the dimensions usual at his age, yet he had more than momentary erections, as he was surrounded

a multitude of dissections to have existed when great excitement of the genitals occurred before death, and injuries of the cerebellum, at the back of the head, have as frequently occasioned impotence. Desire is much stronger in the males of all species than in the females; and, in general, the cerebellum of the male is larger than of the female,—the distance between the mastoid processes is wider; the back of the neck and head, fuller; indeed the whole is much thicker; and if the brains of the two sexes are placed in water, the larger cerebellum of the male is very conspicuous.

The sympathy of the cerebellum with the genitals, is the reason of the latter being regarded as the seat of desire. If they are removed, desire is generally extinguished; for the cerebellum is not afterwards developed at puberty, and the back of the head and neck remains small, perhaps smaller than in the female. If one testicle only is removed, Gall has invariably observed, in experiments on rabbits, and some cases in the human subject, that the opposite half of the cerebellum is not developed[u] or shrinks. Removal of both or one testicle after puberty produces sometimes exactly similar effects. On the other hand, morbid irritation of the genitals will sometimes excite intense desire; and, judging from all the other facts, we should say from exciting the cerebellum. In violent sexual excitement, the back of the neck is flushed, and hotter. Some animals feel the sexual desire at certain periods of the year only; and at this time the testes, and

---

by girls willing to indulge him from the piquant singularity of the thing. He died of consumption before attaining his fourteenth year. His cerebellum was extraordinarily developed; the rest of his head of the common dimensions. In every other respect, indeed, he was only an ill-educated spoiled child."

I beg to omit the argument urged at p. 421, that had Lefort been an imperfect being of either sex, desire would not have been felt,—this being dependent upon the development of the cerebellum, not of the genitals.

[u] In the third volume of his large work, printed in 1818, and some years before this in his lectures, Gall declared, from numerous observations, that the fibres of the medulla spinalis ascending from the genital parts till they reach the cerebellum, decussate exactly like the anterior pyramids. Some years afterwards, M. Serres and M. Fleurens made the same discovery, and contended for priority, not mentioning Gall. It is remarkable how many discoveries of Gall's that were denied or disregarded, have been since made by others, and even frequently contested by two parties, he and his labours being never once thought of. "The greater part of authors," says he, "who have treated of the same subjects as myself, posteriorly to me, practise this same kind of generosity towards me." l. c. t. vi. p. 26.

in some instances the vesiculæ seminales and prostate gland, enlarge very considerably, as in the male sparrow and frog. Gall found the cerebellum of birds collected at this season, broader and more turgid, and the corresponding prominences of the cranium manifestly greater than in those collected at the beginning of winter.

The facts adduced by Gall, on these points, in the third volume of his octavo work, are curious and very numerous; and similar ones, without end, may be found in works upon disease, military surgery, and physiology, from ancient times down to Magendie's Journal for January last year. It occasionally happens, that apoplexy or other disease of the cerebellum, is not attended by affections of the genitals; and I am inclined to believe, that when no excitement of those organs accompanies the disease of the cerebellum, the disease does not include the vermiform process, which is considered by Gall the fundamental part of the cerebellum, from its being the only part always existing in animals where there is a cerebellum.

(E) Not only do instances of early puberty and full growth frequently occur, but likewise of deficient and exuberant growth.

Dwarfs are generally born of the same size as other children, but after a few years suddenly cease to grow. They are said to be commonly ill-shaped, to have large heads, and to be stupid or malicious,[x] and old age comes upon them very early. The three foreign dwarfs exhibited not many years since in London, two men and one woman, had certainly large heads and flat noses, but in other respects were well made. The tallest of the three seemed a sulky creature, but the woman was very ingenious and obliging, and Simon Paap — the least of the three, appeared very amiable. He was twenty-eight inches high, and twenty-six years old. They were not related to each other, and the relations of all were of the common size. Their countenances were those of persons more advanced. The smallest dwarf on record was only sixteen inches high, when thirty-seven years of age.[y] I saw

[x] "It will not be easy to produce me an instance of any one giant or of any one dwarf perfectly sound in heart and mind, *i. e.* in the same degree with a thousand other individuals who are regularly constituted. Great mental weakness is the usual portion of giants, gross stupidity that of dwarfs." Lavater, *Physiognomy*.

[y] Haller, *Elementa Physiologiæ*. t. xii. lib. 30.

a female dwarf, named Crachami, said to be ten years old, who was well-formed, but had the features of a baby, was only nineteen and a half inches in height, and five pounds in weight.[z] Her voice was that of an infant. To hear her speak, and see her walk, sit, and behave like a child several years old, was one of the most striking things I ever witnessed.

The tallest person authentically recorded has never exceeded nine feet, according to Haller. A young man from Huntingdonshire, also exhibited in London a few years back, was of remarkable height. Although only seventeen years of age, he was nearly eight feet. He had a sister of great height, and many of his family were very tall. He was, as is usual, born of the ordinary size, but soon began to grow rapidly. He appeared amiable, and as acute as most youths of his age and rank.

Giants and dwarfs happily seldom reach their fortieth year, and have not very active organs of generation. As the period of growth is so short in dwarfs, and the period of childhood so short in those who reach puberty early, it is to be expected that their old age will be premature,—that their stationary period and decline will be likewise short.[a] Giants do not, like dwarfs, I believe, die from premature old age, but from mere exhaustion.

[z] See *Literary Gazette*, May 1. 1824.

[a] In the year 1748, Mr. Dawkes, a surgeon at St. Ives, near Huntingdon, published a small tract called *Prodigium Willinghamense*, or an Account of a surprising Boy, who was buried at Willingham, near Cambridge, upon whom he wrote the following epitaph. But whether it was ever engraved upon his tombstone I have not learned.

'Stop Traveller, and wondering, know, here buried lie the remains of Thomas, son of Thomas and Margaret Hall; who, not one year old, had the signs of manhood; not three, was almost four feet high; endued with uncommon strength, a just proportion of parts, and a stupendous voice; before six, he died as it were of an advanced age.

'He was born in this village, Oct. 31. MDCCXLI. and in the same, departed this life, Sept. 3. MDCCXLVII.'

Mr. Dawkes viewed him after he was dead, and says the corpse had the aspect of a venerable old man.

See also a description of him in the *Phil. Trans.* 1744–5.

This *perfectly authentic* case removes all doubts respecting the boy at Salamis, mentioned by Pliny (*Hist. Nat.* lib. vii. c. xvii.) as being four feet high, and having reached puberty when only three years old; and respecting the man seen by Craterus, the brother of Antigonus (Phlegon, *De mirab.* c. xxxii.), who in seven years was an infant, a youth, an adult, a father, an old man, and a corpse.

The Laplanders are one of the shortest races. Buffon says that their height is but four feet, and that their tallest men do not exceed four feet and a half.

(F) This change sometimes arises from ovarian disease.[b]

Sir Everard Home mentions a duck, which, when eight years old, not only ceased laying, and acquired the male plumage, but repelled all drakes, and did its best to tread ducks.[c]

(G) The heavenly serenity of the countenance of most fresh corpses is a very remarkable, and to me, I confess, a very affecting and consolatory, circumstance. I cannot deny myself the pleasure of forcibly drawing the attention of my readers to it by quoting some lines of the mighty Byron.

> "He who hath bent him o'er the dead
> Ere the first day of death is fled,
> Before decay's effacing fingers
> Have swept those lines where beauty lingers,
> And mark'd the mild angelic air,
> The rapture of repose that's there,
> The fix'd yet tender traits that streak
> The languor of the placid cheek,
> And, but for that sad shrouded eye
> That fires not — wins not — weeps not now,
> And but for that chill changeless brow,
> Where cold obstruction's apathy
> Appals the gazing mourner's heart,
> As if to him it could impart
> The doom he dreads yet dwells upon,—
> Yes, but for these and these alone,
> Some moments, aye, one treacherous hour,
> He still might doubt the tyrant's power:
> So fair, so calm, so softly seal'd,
> The fair last look by death reveal'd."[d]

Sometimes the features are much changed for a short time after death, and subsequently resume their usual appearance.

Hopkins Hopkins, weighing never more than 18lb. and latterly but 12, died of pure old age at seventeen; and one of his sisters, but 12 years of age, and weighing only 18lbs. at the time of his death, had all the marks of old age. (*Gentleman's Magazine*, vol. xxiv. p. 191.) At the *Hospice de Maternité*, a few years ago, a child is declared to have been born all wrinkled, and with strong grey hair on its head and chin. It appeared in good health, but its hands and feet were of double the usual length. *Tablettes Universelles.*

[b] *Phil. Trans.* 1827.

[c] *Phil. Trans.* 1799, p. 174.

[d] *Giaour.*

(H) Our countryman Parr married when a hundred and twenty years of age, retained his vigour till a hundred and forty, and died at a hundred and fifty-two from plethora, induced by a change in his diet.[e] Harvey, who dissected him, found no decay of any organ,[f] and, had not Parr become an inmate of the Earl of Arundel's family in London, he probably would have lived many years longer. Our other countryman Jenkins, who lived a hundred and sixty-nine years, is, perhaps, the greatest authentic instance of longevity.

Longevity frequently runs in families, and is much disposed to by early rising and matrimony.[g]

The duration of life varies in different countries. Dr. James Johnson says the average of all ranks in the peninsula of India falls $\frac{1}{8}$ below what it is in Europe.[h] In another work we read that the sixtieth year is there seldom attained.[i] On the other hand, Buffon writes that in the American Indians the hair never becomes grey nor the skin wrinkled, and that many Mexicans, especially females, frequently reach their hundredth year, and preserve their muscular force till death. The Laplanders and the people of

[e] At 105 he did penance in a white sheet for an illicit amour, which physiological fact John Taylor the poet, in 1635, immortalised in the following elegant rhymes: —

"Fair Catharine Milton was this beauty bright,
Fair like an angel, but in weight too light,
Whose fervent feature did inflame so far
The ardent fervor of old Thomas Parr,
That for love's satisfaction 'twas thought meet
He should be purged by standing in a sheet;
Which aged he *one hundred and five* year,
In Aldersbury Bury's church did wear.
Should all that so offend such penance do,
Oh! what a price would linen rise unto,
All would be turn'd to sheets, our shirt and s———,
Our table linen, very porter's frock,
Would hardly 'scape transforming. *Eccentric Mirror*, vol. i.

Menstruation has continued regularly till the seventieth year (*Phil. Trans.* 1713), and women have lain in at fifty-four. (*Edinb. Annual Register*, vol. ix.)

[f] *Phil. Trans.* vol. iii. 1699.

[g] See an original and beautiful *Account of the State of the Body and Mind in old Age*, in the *Med. Inquiries and Observations* (vol. ii.) of that most interesting writer, Dr. Rush.

[h] *On the Influence of Tropical Climates.*

[i] *Oriental Field Sports*, vol. i. p. 236.

the northern coasts of Tartary he also remarks, though living under ground during winter, and in the midst of smoke during summer, for the purpose of keeping off the gnats, are seldom sick, and live to an extreme old age, the old being scarcely distinguishable from the young.

Life is often protracted very long after the teeth have fallen out and the hair has turned gray.

Dr. Rush gives a striking illustration of the weakness of impressions made in advanced life, while those of earlier date are well remembered, in the instance of a German woman who had learned the language of the Americans when forty years old, and, though still living in America, had forgotten every word of it at eighty, but talked German as fluently as ever. Bishop Watson's father married and had a family very late, and when extremely aged would twenty times a day ask the name of the lad at college, though he would "repeat, without a blunder, hundreds of lines out of classic authors."[k]

It is a most remarkable circumstance that the system frequently makes an effort at renovation in extreme old age. I myself have known several old persons cut new teeth, and the *Philosophical Transactions*, the *German Ephemerides*, Van Swieten's *Commentaries*, and other works, record many similar facts,—even that of a complete third set.[l] Dr. Rush mentions an old man in Pennsylvania who at sixty-eight lost his sight and remained perfectly blind for years, though otherwise in complete health; at eighty he regained his sight spontaneously without any visible change in the eyes, and could see as well as ever in his life at eighty-four, when the account was written. Dr. Mason Good saw a lady who at an advanced age cut several new teeth, and threw away her spectacles after using them for twenty years, and read the smallest print of newspapers; and another, who with her new teeth, completely recovered her hearing, although she had for many years been so deaf as to be obliged to feel the tongue of her hand-bell for the purpose of ascertaining whether the bell rang or not. In the *Philosophical Transactions* a physician mentions that his father cut two new teeth, which afterwards dropped out together with the rest, when in two years fresh ones

[k] *Anecdotes of the Life and Writings of Bishop Watson*, &c.

[l] John Hunter saw such an instance. *Nat. Hist. of the Teeth.* This was in a female, as I believe is more frequently the case.

appeared, and he at length had an entire new set, and his grey head of hair turned dark. The grey hairs of several old people have become brown or black.[m]

I need scarcely observe that the height and the age of men at present are the same as they were in ancient times. It is a common custom to magnify the past. Homer, who flourished almost three thousand years ago, makes his heroes hurl stones in battle which

——— *οὐ δύο γ᾽ἄνδρε φέροιεν*
Οἷοι νῦν βροτοί εἰσι.[n]

Yet the giant who was the terror of the Israelites did not probably exceed nine feet in height, and it was to David who slew him and flourished but a little more than a century later than Homer's heroes that Barzillai thus excused himself for not visiting the royal palace at Jerusalem: — "I am this day fourscore years old; and can I discern between good and evil? can thy servant taste what I eat or what I drink? can I hear any more the voice of singing men and singing women? wherefore then should thy servant be yet a burden unto my lord the king?"[o] Moses lived five hundred years earlier than David, and writes, — "The days of our years are threescore and ten: and if by reason of strength they be fourscore years, yet is their strength labour and sorrow: for it is soon cut off, and we fly away."[p]

(I) The functions of the human machine having now been fully described, it may be useful to consider it in its relation to other animated systems, and to review the chief varieties in which it appears.

Numerous authors have remarked that a gradation exists among all the objects of the universe, from the Almighty Creator, through arch-angels and angels, men, brutes, vegetables, and inanimate matter, down to nothing.

[m] Examples may be found in Sir John Sinclair's *Code of Health and Longevity*. See also the article Cas Rares, in the *Dictionnaire des Sciences Médicales*.

[n] *Iliad*, lib. v.

[o] 2 *Samuel*, xix. 35.

[p] *Psalm* xc. — ascribed to Moses by most biblical scholars.

"Vast chain of being which from God began,
Natures ethereal, human, angel, man,
Beast, bird, fish, insect, what no eye can see,
No glass can reach, from infinite to thee,
From thee to nothing."[q]

Yet this gradation, striking as it is, deserves not the epithet regular or insensible. "The highest being not infinite must be, as has been often observed, at an infinite distance below infinity." "And in this distance between finite and infinite there will be room for ever for an infinite series of indefinable existence. Between the lowest positive existence and nothing, wherever we suppose existence to cease, is another chasm infinitely deep; where there is room again for endless orders of subordinate beings, continued for ever and ever, and yet infinitely superior to non-existence." "Nor is this all. In the scale, wherever it begins or ends, are infinite vacuities. At whatever distance we suppose the next order of beings to be above man, there is room for an intermediate order of beings between them, and if for one order then for infinite orders; since every thing that admits of more or less, and, consequently, all the parts of that which admits them, may be infinitely divided. So that, as far as we can judge, there may be room in the vacuity between any two steps of the scale, or between any two points of the cone, for infinite exertion of infinite power."[r]

In fact, at how vast a distance do we see the innate mental properties of man standing above those of the most sagacious brute! How immensely does the volition of the lowest animal raise it above the whole vegetable kingdom! And how deep the chasm between the vital organisation of the meanest vegetable and a mass of inanimate matter! Gradation must be admitted, but it is far from regular or insensible. Neither does it at all regard perfection of system, nor very much the degree, but chiefly the excellence, and, within the limits of the visible world, the combination, of properties. Man, placed at the summit of terrestrial objects by the excellence of his mind and the combination of the common properties of matter, of those of vegetables, and of those of brutes, with those peculiar to himself, is surpassed by the dog in acuteness of smell and by the oak in

[q] Pope, *Essay on Man.* Epistle 1.

[r] Dr. Johnson, *Review of a Free Enquiry into the nature and origin of evil.*

magnitude, nor can he boast of more perfection than the gnat or the thistle in their kinds.

Substances consist of Particles endowed with certain properties without which their existence cannot be conceived, *viz.* extension and impenetrability; with others which proceed, indeed, from their existence, but are capable of being subdued by opposing energies, *viz.* mobility, inertness; and with others apparently neither necessary to their existence nor flowing from it, but merely superadded; for example, various attractions and repulsions, and various powers of affecting animated systems.

Inanimate substances may be gaseous, liquid, or solid. If solid, the inanimate body has no properties which are not analogous to these or even dependent upon them. It is for the most part homogeneous in its composition, and disposed to be flat and angular, increases by external accretion, has an indeterminate volume, and contains within itself no causes of decay. The rest of the bodies in nature are *animated*, and are vegetables and animals.

Vegetables, in addition to the properties of inanimate matter, possess those of Life, *viz.* sensibility (without consciousness or perception)—I would say excitability, for sensibility without the power of sensation is nonsense,—and contractility, or rather express both by the term excitability.[s] Their structure is beautifully organised, their volume is determinate, and their surfaces disposed to be curved; they grow by interstitial deposition, changing substances to their own nature, and are destined in their very nature for a limited existence,—a period of increase and decay.

Animals, in addition to the properties of vegetables, enjoy Mind, the indispensable attributes of which are the powers of consciousness and perception, and of volition: the two former,—which are in truth but one, termed consciousness when it takes cognizance of internal impressions, and perception when of external,—without the latter, would be, like vegetable or organic sensibility without contractility, were this possible, useless; and the

[s] By the former, stimuli act upon them, and by the latter, they upon stimuli: by the sensibility and contractility of the vessels, substances are taken up by the roots, and circulated through the system, and converted into the various parts of the vegetable. Yet this does not imply perception, consciousness, or will. The excitability of the absorbents and secretories of our own system carries on absorption and secretion without our consciousness or volition.

latter could not exist without the former,[t] any more than vegetable or organic contraction could occur without excitability: nor can the existence of mind be conceived without the faculties of consciousness, perception, and volition, any more than the existence of matter without extension and impenetrability. The possession of mind by animals necessarily implies the presence of a brain for its exertion, and of a nerve or nerves for the purpose of conveying impressions to this brain, and at least volitions from it to one or more voluntary muscles. A system which is not thus gifted certainly deserves not the name of animal.[u]

Notwithstanding the vast interval which of necessity exists between the animal and vegetable kingdoms, the lowest brutes approach as nearly as possible in organisation, and consequently in function, to vegetable simplicity. They possess merely consciousness and perception, and volition, with the appetite for food, or are even nourished by imbibition, and multiply by shoots, fixed like vegetables to the spot which they inhabit. The five senses, sexual appetite, instincts, memory, judgment,[x] and loco-

[t] "Sense," says Hamlet to his mother, "sure you have,
Else could you not have motion." Act iii. Sc. 4.

[u] I cannot conceive an animal without consciousness, perception, and volition; nor can I conceive these in an animal without a brain, any more than the secretion of bile without a liver or something analogous. I contend not for the name, but for the thing. Zoologists indeed affirm that many internal worms and all the class of zoophytes have no nervous system. But comparative anatomy is yet imperfect, the examination of minute parts is extremely difficult, and new organs are daily discovered. Blumenbach, after remarking that, except those animals which inhabit corals and the proper zoophytes, most genera of the other orders of the Linnæan class of vermes are found to possess a distinct nervous system, adds: "Although former anatomists have expressly declared in several instances that no such parts existed." (*Comparative Anatomy*, ch. cxvi. F.) Besides, some beings have been denominated animals without any very satisfactory reason.

Where the nervous system of an animal cannot be readily detected, its presence may be inferred from motions evidently voluntary, such as retraction upon the approach of footsteps, — proving the existence of an organ of hearing, a brain, and nerves: motion in a part *directly* stimulated, as the contraction of an hydatid upon being punctured, is no proof of an animal nature, for this is common to vegetables, for instance, the leaves of the *dionæa muscipula*, which contract forcibly on a slight irritation. It may likewise be inferred from the presence of a stomach, because, where there is a stomach, the food is taken in, not by absorbing vessels constantly plunged in it, but by a more or less complicated and generally solitary opening regulated by volition. John Hunter contended that the stomach was the grand characteristic of the animal kingdom.

[x] I see daily instances of something deserving some such name as judgment

motive power, with the necessary organs, are variously superadded, and endless varieties of organisation constructed, so that air and water, the crust and the surface of the earth, are all replenished with animals completely calculated for their respective habitations.[y]

---

or reason in brutes. To the incredulous I offer the following anecdote in the words of Dr. Darwin. "A wasp on a gravel walk had caught a fly nearly as large as itself. Kneeling on the ground, I observed him separate the tail and the head from the body part to which the wings were attached. He then took the body part in his paws and rose about two feet from the ground with it; but a gentle breeze wafting the wings of the fly turned him round in the air and he settled again with his prey upon the gravel. I then distinctly observed him cut off with his mouth first one of the wings and then the other, after which he flew away with it unmolested with the wind." *Zoonomia:* Instinct. — The works of the two Hubers *Sur les abeilles* and *Sur les mœurs des fourmis indigènes* furnish an abundance of most interesting instances of reason in those insects. See also Mr. Smellie's paper in the *Transact. of Royal Society of Edinburgh*, vol. i. p. 39. sqq.

[y] An error has been committed not only in representing the gradation regular, but in supposing every species of animal to constitute a distinct step in the gradation. "The whole chasm in nature," says Addison (*Spectator*, No. 519.), "from a plant to a man, is filled up with divers kinds of creatures, rising one above another, by such a gentle and easy ascent, that the little transitions and deviations from one species to another are almost insensible." "All quite down from us," says Locke (*Essay on the Human Understanding*. b. iii. c. 6.), "the descent is by easy steps, and a continued series of things, that in each remove differ very little one from the other. There are fishes that have wings, and are not strangers to the airy region; and there are some birds, that are inhabitants of the water; whose blood is cold as fishes, and their flesh so like in taste that the scrupulous are allowed them on fish days. There are animals so near of kin both to birds and beasts, that they are in the middle between both: amphibious animals link the terrestrial and aquatic together, seals live at land and at sea, and porpoises have the warm blood and entrails of a hog; not to mention what is confidently reported of mermaids or sea men." "In respect of our intellectual and moral principles," remarks Mr. Dugald Stewart (*Outlines of Moral Philosophy*, par. 109), "our nature does not admit of comparison with that of any other inhabitant of this globe: the difference between our constitution and theirs being a difference, not in degree, but in kind. Perhaps this is the single instance in which that regular gradation which we, every where else, observe in the universe, fails entirely."

Now the various kinds of animals do certainly run into each other; — there are no great peculiarities of construction in single organs between which and the ordinary structure of the same organs in other animals an intermediate structure connecting the two are not continually brought to light by naturalists. No two are so different but that discoveries are continually made of a third intermediate.

Man, besides the common properties of animals, has others which raise him to an immense superiority. His mind is endowed with powers of the highest order that brutes have not, and his body being, like the bodies of all animals, constituted in harmony with the mind that the powers of the latter may have effect, differs necessarily in many points of construction from the body of every brute. Well might Shakspeare exclaim, "What a piece of work is man! How noble in reason! how infinite in faculties! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals!"[z]

The orang-outangs approach the nearest of all brutes to the human subject. Possessing expression of countenance, elevation of forehead, and less projection of the lower part of the face than other brutes, anterior extremities that are really arms and hands, and teeth of the same number and pretty much of the same figure as our own; curious, imitative, covetous, social; said by some to place sentinels and dispose themselves in a train for the propagation of alarm; to seem now and then to laugh and weep,[a] to walk a little occasionally erect, to defend themselves with sticks and stones, to copulate face to face, to carry their young either in their arms or on their backs, and to be very lascivious in regard to our species; the orang-outangs at first sight afford, if any of the genus can afford, a little probability to the opinion of a close connection between apes and the human race. Uncivilised men, too, make a slight approach in many corporeal

---

But connection is not gradation. Many kinds, and the intermediate ones by which they are united, are all on a level in point of excellence and combination of properties, so that a single step in the gradation may comprehend a great number of kinds: — the whole vegetable kingdom forms but one step.

[z] *Hamlet*, Act ii. Sc. 2.

[a] Le Cat (*Traité de l'Existence du fluide des nerfs*, p. 35.), asserts that he had seen the jocko or chimpansé (*simia troglodytes*) both laugh and cry. The reader will remember the lines in Milton's Paradise Lost (B. ix.),—

> "Smiles from reason flow,
> To brute denied."

The orang-outangs exhibited a few years ago at Exeter-'Change, — the one a satyrus and the other a chimpansé, are said by their keepers to have sometimes laughed when much pleased, but never to have wept. Steller states the fact of weeping in regard to the phoca ursina; Pallas, in regard to the camel; and Humboldt, in regard to a small American monkey. Mr. Lawrence, *Lectures*, p. 236.

particulars, as we shall hereafter find, to the structure of other animals, and since, also, the circumstances of their existence call into action few of the peculiar mental powers of our nature, they have been adduced in corroboration of this opinion. But *the least examination* displays differences of the greatest magnitude between the human and the brute creation.[b] These we shall review under two divisions, the first embracing the mental, and the second the corporeal, characteristics of mankind.

In judging of the *mental* faculties of mankind,[c] not merely those should be considered which an unfortunately situated individual may display, but those which all the race would display under favourable circumstances. A seed and a pebble may not on a shelf appear very dissimilar, but, if both are placed in the earth, the innate characteristic energies of the seed soon become

[b] In La Fontaine's charming fable of *Le Singe et le Dauphin*, the former during a shipwreck, near Athens, resolves to profit by his resemblance to man, for whom the dolphin was anciently said to have a great regard. (See Pliny, *Hist. Nat.* ix. 8, 9.) In the hurry,

> Un dauphin le prit pour un homme,
> Et sur son dos le fit asseoir
> Si gravement, qu'on eut cru voir
> Le chanteur que tant on renomme.

Just before landing him, the dolphin asked whether he often saw the Piræus, to which he unfortunately replied,

> Tous les jours : il est mon ami :
> C'est une vieille connaissance.

One glance was sufficient to discover the difference between a man and a monkey.

> Le dauphin rit, tourne la tête ;
> Et, le magot considéré,
> Il s'apperçoit qu'il n'a tiré
> Du fond des eaux rien qu'une bête ;
> Il l'y replonge, et va trouver
> Quelque homme à fin de le sauver.

"The difference between the volume of the brain of the orang-outang and man is as 5 to 1 : their convolutions differ considerably in number and structure ; the anterior lobes especially are narrowed into a cone, flattened above, hollowed out below, &c. and the difference is much more striking in other apes." Gall, l. c. t. vi. p. 298.

[c] In the external senses of at least smelling, hearing, and seeing, man is surpassed by brutes. Whether they have any sense not possessed by us I cannot pretend to say.

conspicuous. A savage may in the same manner seem little superior to an orang-outang, but, if instruction is afforded to both, the former will gradually develope the powers of our nature in all their noble superiority, while the latter will still remain an orang-outang. The excellence of man's mind demonstrates itself chiefly by his voice and hands. Witness the infinite variety and the depth of thought expressed by means of words: witness his great reasoning powers, his ingenuity, his taste, his upright, religious, and benevolent, feelings, in his manufactories, his galleries of the fine arts, his halls of justice, his temples, and his charitable establishments. Besides the qualities common to all animals, each of which he, like every animal, possesses in a degree peculiar to himself, and some indeed in a degree very far surpassing that in which any brute possesses them, for instance, benevolence, mechanical contrivance, the sense for music and language, and the general power of observation and inference respecting present circumstances, he appears exclusively gifted with at least feelings of religion and justice, with taste, with wit, and with decided *reflecting* faculties of comparing and reasoning into causes.

The *corporeal* characteristics of mankind are not less striking and noble.[d] Among the beings beheld by Satan in Milton's Paradise,

> " Two of far nobler shape, erect and tall,
> Godlike erect, with native honour clad,
> In naked majesty seem'd lords of all." [e]

The erect posture is natural and peculiar to man.[f] All nations

[d] Consult Blumenbach, *De Generis Humani Varietate Nativa*. Sect. i. De hominis a cæteris animalibus differentia.

[e] *Paradise Lost*, book iv. 288.

[f] There is little necessity in the present day to attempt the refutation of the ridiculous opinion that man is destined to walk on all-fours. But I do so for the purpose of displaying many peculiarities of our structure.

It is almost incredible that a thinking man could have entertained it for a moment, any more than the idea of our naturally having tails. Yet this is the fact; and, in exquisite ridicule of such philosophers, Butler makes Hudibras, after proving to his mistress by his beard that he is no gelding, fruitlessly urge his erect posture in proof that he is not a horse.

> " Next it appears I am no horse,
> That I can argue and discourse,
> Have but two legs, and ne'er a tail. —
> Quoth she, That nothing will avail ;

walk erect, and, among those individuals who have been discovered in a wild and solitary state, there is no well authenticated instance of one whose progression was on all-fours. If we attempt this mode of progression, we move either on the knees or the points of the toes, throwing the legs obliquely back to a considerable distance; we find ourselves insecure and uneasy; our eyes instead of looking forwards are directed to the ground; and the openings of the nostrils are no longer at the lower part of the nose,—in a situation to receive ascending odorous particles, but lie behind it. Our inferior extremities, being of much greater length, in proportion to the others and to the trunk, than the posterior of brutes with four extremities, even in children in whom the proportion is less, are evidently not intended to coincide with them in movement; they are much stronger than the arms, obviously for the purpose of great support: the presence of calves, which are found in man alone, shows that the legs are to support and move the whole machine; the thigh bones are in the same line with the trunk, in quadrupeds they form an angle, frequently an acute one; the bones of the tarsus become hard and perfect sooner than those of the carpus, because strength of leg is required for standing and walking sooner than strength of arm and hand for labour; the great toe is of the highest importance to the erect posture, and bestowed exclusively on mankind; the os calcis is very large, particularly at its posterior projection, for the insertion of the strong muscles of the calf, and lies at right angles with the leg; we alone can rest fully upon it, and in fact upon the whole of the tarsus, metatarsus, and toes. The superior extremities do not lie under the trunk as they would if destined for its support, but on its sides, capable of motion in every direction towards objects; the fore-arm extends itself outwards, not forwards, as in quadrupeds, where it is an organ

---

For some philosophers of late here
Write, men have four legs by nature,
And that 'tis custom makes them go,
Erroneously upon but two.
As 'twas in Germany made good
B' a boy that lost himself in a wood,
And growing to a man was wont
With wolves upon all-four to hunt."

Hudibras, part ii. canto i.

of progression; the hand is fixed not at right angles with the arm, as an instrument of support, but in the same line, and cannot be extended to a right angle without painfully stretching the flexor tendons; the superior extremity is calculated in the erect posture for seizing and handling objects, by the freedom of its motions, by the great length of the fingers above that of the toes, and by the existence of the thumb, which, standing at a distance from the fingers and bending towards them, acts as an opponent, while the great toe is, like the rest, too short for apprehension, stands in the same line with them, and moves in the same direction: were our hands employed in the horizontal posture, they would be lost to us as grand instruments in the exercise of our mental superiority. Quadrupeds have a strong ligament at the back of the neck to sustain the head; in us there is no such thing, and our extensor muscles at the back of the neck are comparatively very weak.[g] They have the thorax deep and narrow, that the anterior extremities may lie near together and give more support; the sternum too is longer, and the ribs extend considerably towards the pelvis to maintain the incumbent viscera; our thorax is broad from side to side, that the arms being thrown to a distance may have greater extent of motion, and shallow from the sternum to the spine; and the abdominal viscera, pressing towards the pelvis rather than towards the surface of the abdomen in the erect attitude, do not here require an osseous support. The pelvis is beautifully adapted in us for supporting the bowels in the erect posture; it is extremely expanded, and the sacrum and os coccygis bend forwards below: in brutes it does not merit the name of pelvis; for, not having to support the abdominal contents, it is narrow, and the sacrum inclines but little to the pubes. The nates, besides extending the pelvis upon the thigh bones in the erect state of standing or walking, allow us to rest while awake in the sitting posture, in which, the head and trunk being still erect, our organs of sense have their proper direction equally as in walking or standing: were we compelled to lie down like quadrupeds, when resting during the waking

[g] As the head is connected with the trunk farther back in brutes than in us, the small length of lever between the occipital foramen and the back of the head, and the length of the head below the foramen, require all this power; but even in us much more upholding power than we have at the back of the neck would be required for all-four progression, as the head would no longer rest upon the spine.

state, the different organs of the face must change their present situation to retain their present utility, no less than if we were compelled to adopt the horizontal progression; and, conversely, were their situation so changed, the provision for the sitting posture would be comparatively useless.

While some, perversely desirous of degrading their race, have attempted to remove a splendid distinction by asserting that we are constructed for all fours, others with equal perverseness and ignorance have asserted that monkeys are destined for the upright posture. The monkey tribe, it is true, maintain the erect posture less awkwardly than other brutes with four extremities, but they cannot maintain it long, and, while in it, they bend their knees and body; they are insecure and tottering, and glad to rest upon a stick; their feet, too, instead of being spread for support, are coiled up as if to grasp something. In fact their structure proves them to be neither biped nor quadruped, but four-handed, animals. They live naturally in trees, and are furnished with four hands for grasping the branches and gathering their food. Of their four hands the posterior are even the more perfect, and are in no instance destitute of a thumb, although, like the thumbs of all the quadramana, so insignificant as to have been termed by Eustachius, "omnino ridiculus;" whereas the anterior hands of one variety (*simia paniscus*) have not this organ. The whole length of the orang-outang, it may be mentioned, falls very much short of ours.

It was anciently supposed that man, because gifted with the highest mental endowments, possessed the largest of all brains. But as elephants and whales surpass him in this respect, and the sagacious monkey and dog have smaller brains than the comparatively stupid ass, ox, and hog, the opinion was relinquished by the moderns, and man was said only to have the largest brain in proportion to the size of his body. But as more extensive observation proved canary and other birds, and some varieties of the monkey tribe, to have larger brains than man in proportion to the body, and several mammalia to equal him in this particular, and as rats and mice too surpass the dog, the horse, and the elephant, in the comparative bulk of their brains, this opinion also gave way, in its turn, to that of Söemmerring, — that man possesses the largest brain in comparison with the nerves arising from it. This has not yet been contradicted, although the comparative size of the brain to the nerves originating from it (grant ing that they originate from it) is not an accurate measure of the faculties, because the seal has in proportion to its nerves a larger brain than the house-dog, and the porpoise than the orang-outang.[h]

As the human brain is of such great comparative magnitude, the cranium is necessarily very large and bears a greater proportion to the face than in any other animal. In an European the vertical section of the cranium is almost four times larger than that of the face (not including the lower jaw); in the monkey it is little more than double; in most feræ, nearly equal; in the glires, solipedes, pecora, and belluæ, less. The faculties, however, do not depend upon this proportion, because men of great genius, as Leo, Montaigne, Leibnitz, Haller, and Mirabeau, had very large faces, and the sloth and seal have faces larger than the stag, horse, and ox, in proportion to the brain, and the proportion is acknowledged by Cuvier to be not at all applicable to birds. We are assisted in discovering the proportion between the cranium and face by the facial angle of Camper. He draws two straight lines, the one, horizontal, passing through the external meatus auditorius and the bottom of the nostrils; the other, more perpendicular, running from the convexity of the forehead to the most prominent part of the upper jaw. The angle which the latter, — the proper facial line, makes with the former, is greatest in the human subject, from the comparative smallness of the brain and the great development of the mouth and nose in brutes. In the human adult this angle is about from 65° to 85°; in the orang-outang about from 55° to 65°; in some quadrupeds 20°; and in the lower classes of vertebral animals it entirely disappears.

Neither is it to be regarded as an exact measure of the understanding, for persons of great intellect may have a prominent mouth; it shows merely the projection of the forehead, while the cranium and brain may vary greatly in size in other parts; three-fourths of quadrupeds, whose crania differ extremely in other respects, have the same facial angle; great amplitude of the frontal sinuses, as in the owl and hog, without any increase of brain, may increase it, and for this reason Cuvier draws the facial line from the internal table of the frontal bone.

In proportion as the face is elongated, the occipital foramen lies more posteriorly; in man consequently it is most forward. While in man it is nearly in the centre of the base of the cranium, and horizontal, and has even sometimes its anterior margin

[h] See Gall. l. c. t. ii. p. 281. sqq.

elevated; in most quadrupeds it is situated at the extremity of the cranium obliquely, with its posterior parts turned upwards, and is in some completely vertical. On this difference of situation, Daubenton founded his occipital angle.[i] He drew one line from the posterior edge of the foramen to the lower edge of the orbit, and another, in the direction of the foramen, passing between the condyles and intersecting the former. According to the angle formed, he established the similarity and diversity of crania. The information derived from it in this respect is very imperfect, because it shows the differences of the occiput merely. Blumenbach remarks that its variations are included between 80° and 90° in most quadrupeds which differ very essentially in other points.

The want of the ossa intermaxillaria has been thought peculiar to mankind. Quadrupeds, and nearly all the ape tribe, have two bones between the superior maxillary, containing the dentes incisores when these are present, and termed ossa intermaxillaria, incisoria, or labialia. But these do not exist universally in them.[k] Man only has a prominent chin: his lower jaw is the shortest, compared with the cranium, and its condyles differ in form, direction, and articulation, from those of any brute (Sect. XXI. Note H.): in no brute are the teeth arranged in such a close and uniform series; the lower incisores, like the jaw in which they are fixed, are perpendicular, — a distinct characteristic of man, for in brutes they slope backwards with the jaw bone; the canine are not longer than the rest, nor insulated as in monkeys; the molares differ from those of the orang-outang and of all the genus simia by their singularly obtuse projections.

The slight hairiness of the human skin in general, although certain parts, as the pubes and axillæ, are more copiously furnished with hair than in brutes; the omnivorous structure of the alimentary canal (Sect. XXI. Note G.); the curve of the vagina corresponding with the curve of the sacrum formerly mentioned (page 548.), preventing woman from being, as brute females are, retromingent; the peculiar structure of the human uterus and

[i] *Mémoires de l'Academie des Sciences de Paris.* 1764.

[k] In a chimpansé that died at Exeter Change a few years ago, the statement of Tyson and Daubenton was verified, — that this black ape has no intermaxillary bone. The red-haired variety (*Simia Satyrus*) has it, and is destitute of nails on the hind thumbs and of ligamentum teres at the head of the os femoris, both which structures this chimpansé possessed. The Satyrus is therefore not so near the human subject as the Troglodytes.

placenta; the length of the umbilical chord and the existence of the vesicula umbilicalis until the fourth month; together with the extreme delicacy of the cellular membrane; are likewise structural peculiarities of the human race. The situation of the heart lying not upon the sternum, as in quadrupeds, but upon the diaphragm, on account of our erect position, — the basis turned not, as in them, to the spine, but to the head, and the apex to the left nipple; the absence of the allantois, of the panniculus carnosus, of the rete mirabile arteriosum, of the suspensorius oculi; and the smallness of the foramen incisivum, which is not only very large in brutes, but generally double, though not peculiarities, are striking circumstances.

Man only can live in every climate;[1] he is the slowest in arriving at maturity, and, in proportion to his size, he lives the longest of all mammalia; he only procreates at every season, and, while in celibacy, experiences nocturnal emissions. None but the human female menstruates.

Man, thus distinguished from all other terrestrial beings, evidently constitutes a separate species: — Fact harmonises with the Mosaic account of his distinct creation. For "a species comprehends all the individuals which descend from each other, as from a common parent, and those which resemble them as much as they do each other;" and no brute bears such a resemblance to man.[m]

He is subject, however, to great variety, so great indeed that some writers have contended that several races of men must have been originally created. We shall now examine the principal of these varieties.

The most generally approved division of mankind is that of Blumenbach.[n] He makes five varieties; the Caucasian, Mongolian, Ethiopian, American, and Malay. The following are the characteristics of each.

1. The Caucasian. The skin white; the cheeks red, — almost a peculiarity of this variety; the hair of a nut-brown, running on

[1] Blumenbach accounts for this, and I think justly, by the two-fold operation, of our intellect (l. c. § 18. p. 54.), and of the more accommodating nature of our frame (l. c. § 17.)

[m] Cuvier, *Discours Préliminaire aux recherches sùr les ossemens Fossiles des Quadrupèdes.*

[n] l. c. Sect. IV.

the one hand into yellow, and on the other into black, soft, long, and undulating.

The head extremely symmetrical, rather globular; the forehead moderately expanded; the cheek-bones narrow, not prominent, directed downwards from the malar process of the superior maxillary bone; the alveolar edge round; the front teeth of each jaw placed perpendicularly.

The face oval and pretty straight; its parts moderately distinct, the nose narrow and slightly aquiline, or at least its dorsum rather prominent; the mouth small; the lips, especially the lower, gently turned out; the chin full and round: — in short, the countenance of that style which we consider the most beautiful.

This comprehends all Europeans except the Laplanders and the rest of the Finnish race; the western Asiatics as far as the Obi, the Caspian, and the Ganges; and the people of the North of Africa.

2. The Mongolian. The skin of an olive colour; the hair black, stiff, straight, and sparing.

The head almost square; the cheek bones prominent outwards; the space between the eyebrows, together with the bones of the nose, placed nearly in the same horizontal plane with the malar bones; the superciliary arches scarcely perceptible; the osseous nostrils narrow; the fossa maxillaris shallow; the alveolar edge arched obtusely forwards; the chin somewhat projecting.

The face broad and flattened, and its parts consequently less distinct; the space between the eyebrows very broad as well as flat; the cheeks not only projecting outward, but nearly globular; the aperture of the eye-lids narrow, — linear; the nose small and flat.

This comprehends the remaining Asiatics, except the Malays of the extremity of the Transgangetic peninsula; the Finnish races of the North of Europe, — Laplanders, &c.; and the Esquimaux diffused over the most northern parts of America, from Behring's Strait to the farthest habitable spot of Greenland.

3. Ethiopian. The skin black; the hair black and crisp.

The head narrow, compressed laterally; the forehead arched; the malar bones projecting forwards; the osseous nares large; the malar fossa behind the infra-orbitar foramen deep; the jaws lengthened forwards; the alveolar edge narrow, elongated, more elliptical; the upper front teeth obliquely prominent; the lower jaw large and strong; the cranium usually thick and heavy.

The face narrow and projecting at its lower part; the eyes prominent; the nose thick and confused with the projecting cheeks; the lips, especially the upper, thick; the chin somewhat receding.

The legs in many instances bowed.

This comprehends the inhabitants of Africa; with the exception of those in the northern parts, already included in the Caucasian variety.

4. The American. The skin of a copper colour; the hair black, stiff, straight, and sparing.

The forehead short; the cheek bones broad, but more arched and rounded than in the Mongolian variety, not, as in it, angular and projecting outwards; the orbits generally deep; the forehead and vertex frequently deformed by art; the cranium usually light.

The face broad, with prominent cheeks, not flattened, but with every part distinctly marked if viewed in profile; the eyes deep; the nose rather flat, but still prominent.

This comprehends all the Americans excepting the Esquimaux,

5. The Malay. The skin tawny; the hair black, soft, curled, thick, and abundant.

The head rather narrow; the forehead slightly arched; the parietal bones prominent; the cheek-bones not prominent; the upper jaw rather projecting.

The face prominent at its lower part; not so narrow as in the Ethiopian variety, but the features, viewed in profile, more distinct; the nose full, broad, bottled at its point; the mouth large.

This comprehends the inhabitants of the Pacific Ocean, of the Marian, Philippine, Molucca, and Sunda isles, and of the peninsula of Malacca.

General Remarks. The colour of the hair thus appears somewhat connected with that of the skin, and the colour of the iris is closely connected with that of the hair. Light hair is common with a white and thin skin only, and a dark thick skin is usually accompanied by black hair; if the skin happens to be variegated, the hair also is variegated; with the cream-white skin of the albino,[o] we find hair of a peculiar yellowish white tint; and, where the skin is marked by reddish freckles, the hair is red. When the hair is light, the iris is usually blue; when dark, it is of a brownish black; if the hair loses the light shade of infancy, the iris likewise grows darker, and when the hair turns grey in advanced life, the iris loses much of its former colour; the albino has no more colouring matter in his choroid or iris than in his skin, and they therefore allow the redness of their blood to appear, the latter being of a pale rose-colour and semi-pellucid, the former, from its greater vascularity, causing the pupil to be intensely red; those animals only whose skin is subject to varieties, vary in the colour of the iris; and if the hair and skin happen to be variegated, the iris is observed likewise variegated.[p]

The Caucasian variety of head, nearly round, is the mean of

[o] Albinos spring up among all races of men; and they cannot be accounted for, except when descended from albinos, for this variety of body may be hereditary no less than it is connate and irremediable. It is known to be common to some mammalia and birds, but has never been observed by Blumenbach in cold-blooded animals, (l. c. § 78.) A white rabbit is an instance of an albino. The absence of the pigmentum nigrum renders the eyes extremely sensible to light, whence such persons prefer going out in the evening. In Wafer's well-known and amusing account of those he found in the isthmus of Darien, he says, "They see not well in the sun, poring in the clearest day; their eyes being weak; and running with water if the sun shine towards them; so that in the day time they care not to go abroad, unless it be a cloudy dark day. Besides they are a weak people in comparison of the others, and not very fit for hunting and other laborious exercises, nor do they delight in such, but notwithstanding their being thus sluggish and dull in the day time, yet when moonshiny nights come, they are all life and activity, running abroad and into the woods, skipping about like wild bucks; and turning as fast by moonlight, even in the gloom and shade of the woods, as the other Indians by day, being as nimble as they, though not so strong and lusty." Dampier's *Voyages*.

Blumenbach was the first who conjectured the true nature of the peculiarities of the albino.

[p] The hair is frequently of different shades in different parts.

John Hunter remarked that the iris in animals agrees principally with the colour of the eyelashes.

However various the colour of the hair in horses, the iris, he also observes, is always of the same. But then the hair is always of the same at birth, and the skin does not participate in its subsequent changes, being as dark in white as in black horses. In cream-coloured horses, indeed, there is an exception, — the iris agrees with the hair, but then the foals are originally cream-coloured and the skin is cream-coloured. Hunter, *On the colour of the pigmentum of the eye in different animals*, l. c. p. 247.

the rest, while the Mongolian, almost square, forms one extreme, having the American intermediate, and Ethiopian the other extreme, having the Malay intermediate, between it and the Caucasian.

The Caucasian variety of face is also the mean, while the Mongolian and American, extended laterally, form one extreme, and the Ethiopian and Malay, extended inferiorily, constitute the other. In the first of each extreme, *viz.* the Mongolian and Ethiopian, the features are distinct, while in the second, *viz.* the American and Malay, they are somewhat blended.

Although this division of mankind is well founded and extremely useful, it is liable, like every artificial division of natural objects, to many exceptions. Individuals belonging to one variety are not unfrequently observed with some of the characteristics of another;[q] the characteristics of two varieties are

[q] "Sooty blackness is not peculiar to the Ethiopian, but is occasionally found in other varieties of men very different and remote from each other, in the Brazilians, Californians, Indians, and some South Sea Islanders; and among the latter, the new Caledonians form an insensible transition with the chesnut coloured inhabitants of Tongatabu from the tawny Otaheitans to the black New Hollanders." Blumenbach, l. c. § 43.

"Some tribes of Ethiopians have long hair (Bruce on the Gallas; African Institution on the people of Bornu); on the contrary, some copper-coloured people have the crisp hair of the Ethiopian (the inhabitants of the Duke of York's island, near New Ireland; Vide Hunter, *Historical Account of the proceedings at Port Jackson*). Again, the hair of the New Hollanders, specimens of which I have now before me, is so perfectly intermediate between the crisp hair of the Ethiopian and the curly hair of the islanders of the Pacific ocean, that there has been much diversity of opinion, from the first Dutch to the latest English travellers, to which of the two varieties it should be referred. As to the varieties of colour existing among nations whose hair is usually black, we have sufficient authority for asserting that numerous instances of red hair occur in all the three last varieties." l. c. § 52.

"The Caffres and the people of Congo have hair not unlike that of Europeans. Even the Foulahs, one of the Negro tribes of Guinea, have, according to Mr. Park, soft, silky hair; on the other hand, the inhabitants of many other countries resemble the Africans in their hair, as the savages of New Guinea, Van Diemen's land, and Mallicollo. And in the same island some of the people are found with crisp and woolly, others with straight hair, as in the New Hebrides. In New Holland there are tribes of each character, though resembling in other particulars." J. C. Prichard, M. D. *Researches into the Physical History of Man*, Ed. 1. p. 83.

"Many tribes of the Negro race approach very near to the form of Europeans. The Jaloffs of Guinea, according to Park, are all very black, but they often intimately blended in the same individual (indeed all the four varieties run into each other by insensible degrees);[r] and instances continually occur of deviation in one or more particulars from the appearances characteristic of any variety;[s] so that the assemblage rather than individual marks must frequently be employed to determine the variety.

Particular Remarks. The Caucasian variety is pre-eminent in all those mental and corporeal particulars which distinguish man from brutes. It is to the two sexes of this variety that Milton's lines apply, —

> " For contemplation he and valour formed;
> For softness she and sweet attractive grace." [t]

The cranium is very capacious, the area of the face bears to its area but a proportion of one to four, and projects little or not

---

have not the characteristic features of the Negro — the flat nose and thick lips: and Dampier assures us that the natives of Natal in Africa have very good limbs, are oval-visaged, that their noses are neither flat nor high, but very well proportioned; their teeth are white, and their aspect altogether graceful. The same author (Dampier's *Voyages*) informs us, that their skin is black, and their hair crisped. Nor are others of this diversity more constant. In the native race of Americans, some tribes are found, who differ not in the characters in question from Europeans. ' Under the 54° 10′ of north latitude,' says Humboldt, ' at Cloak-bay, in the midst of copper-coloured Indians, with small long eyes, there is a tribe with large eyes, European features, and a skin less dark than that of our peasantry.' Humboldt's *Essay on New Spain*, translated." l. c. p. 62. note b.

" The features of the inhabitants of the Friendly Islands are very various, insomuch that it is scarcely possible to fix on any general likeness by which to characterize them, unless it be a fulness at the point of the nose, which is very common. But on the other hand we met with hundreds of truly European faces, and many genuine Roman noses among them." Cook's last Voyage. Vol. I. 380.

" Similar examples," remarks Blumenbach on this passage (l. c. § *55.* note.), " are observed, among Ethiopian and American nations; and, *vice versa*, the resemblance of individual Europeans to Ethiopians and Mongoles is very frequent and has become even proverbial."

[r] " The Tartars of the Caucasian variety pass by means of the Kirghises and neighbouring people into the Mongoles, in the same manner as these by means of the people of Thibet into the Indians, by means of the Esquimaux into the Americans, and by means of the Phillippine Islanders even in some measure into the Malays." Blumenbach, l. c. § 86.

[s] See note ". p. *556*.

[t] *Paradise Lost*, book iv. 297.

at all at the lower parts: the intellectual faculties of its individuals are susceptible of the highest cultivation, while the senses of smelling, hearing, and seeing, are much less acute than in dark nations. Philosophy and the fine arts flourish in it as in their proper soil.

The Ethiopian variety when instructed by the Caucasian has produced instances of mental advancement great indeed, but inferior to what the latter is capable of attaining. "There scarcely ever," says Hume, "was a civilized nation of that complexion, nor even an individual, eminent either in action or speculation. No ingenious manufactures amongst them, no arts, no sciences. On the other hand, the most rude and barbarous of the whites, such as the ancient Germans, the present Tartars, have still something eminent about them, in their valour, form of government, or some other particulars." [u] Blumenbach, however, possesses English, Dutch, and Latin poetry written by different negroes, and informs us that, among other examples of distinguished negroes, a native of Guinea, eminent for his integrity, talents, and learning, took the degree of doctor in philosophy at the University of Wittemberg, and that Lislet of the isle of France was chosen a corresponding member of the French Academy of Sciences. "Provinces of Europe," says he, "might be named, in which it would be no easy matter to discover such good writers, poets, philosophers, and correspondents of the French Academy; and, on the other hand, there is no savage people which have distinguished themselves by such examples of perfectibility, and even capacity for scientific cultivation, and consequently, that none can approach more nearly than the negro to the polished nations of the globe." [x] This mental inferiority is attended of course by a corresponding inferiority of the brain. The circumference, diameters, and vertical arch of the cranium being smaller than in the European, [y] and the forehead particularly being narrower and falling back in a more arched form, the brain in general, and particularly those parts which are the organs of intellect properly so called, must be of inferior size. The orbits, on the contrary, and the olfactory and gustatory, or, rather, masticatory, organs being more amply evolved, the area

[u] Hume, *Essays*. Part I. Essay 21. Note M.

[x] *Beyträge zur Naturgeschichte*. Th. i. p. 98.

[y] Soemmerring, *De basi cranii et originibus nervorum cranio egredientium.*

of the face bears a greater proportion to the area of the skull,—as 1. 2. to 4.; the proportion is greater in the orang-outang, and in the carnivora nearly equal.[z] The senses here situated, as well as that of hearing, are astonishingly acute, though not only in this, but also in the three following varieties, and the corresponding nerves, at least the first, fifth, and facial, of great size.[a]

The ossa nasi lie so flatly as to form scarcely any ridge; the face, as we have formerly seen, projects considerably at its lower part;[b] the lower jaw is not only long but extremely strong; the

[z] Cuvier, *Léçons d'Anatomie Comparée.*

[a] Soemmerring, l. c.

The native Americans pursue their enemies through the desert by the sense of smell, and have distinct terms for the odour of an European, a Negro, and an American Indian. (Humboldt, *Political Essay on New Spain.* Translated. vol. i. p. 245. Haller, *El. Phys.*) Negroes in the Antilles can distinguish blacks from whites in pursuit by the same sense. The bodies of all men have doubtless a peculiar odour, though the inferior races only enjoy the sense of smell sufficiently acute to make very nice distinctions in regard to it. In them, too, it is much stronger. I recollect walking one night many years ago with a physician,—Dr. Walshman, to the house of a poor man in the suburbs of the town. The wife came to the door with a candle in her hand, and, opening a dark room on one side of the passage, begged me to walk into it while she lighted the physician to her husband. My nose was presently struck by a very strong smell, something like that of bacon. At the return of the light I perceived three or four little mulattos asleep in a sort of bed, and after leaving the house Dr. Walshman informed me that the woman's husband was a black.

[b] Camper, (*Dissertation physique sur les différences réelles, que presentent les traits du visage chez les hommes de différens pays et différens ages*) gives the following proportions of the facial angle :

European - - -	80 or 90
Chinese - - -	75
Negro - - -	70
Orang-outang - -	58
Monkey - - -	42

Mr. White of Manchester (*Essay on the regular gradation*) states them rather differently :

European - - -	80 to	90
Asiatic - - -	75	80
American - - -	70	75
African - - -	60	70
Orang-outang - - -	50	60
Monkey - - -	40	50

Cuvier gives 75° for the facial angle of the young orang-outang, l. c. viii. Art. i.

chin not only not prominent but even receding, and the space between it and the lower teeth is small, while that between the upper teeth and the nose is large; the meatus auditorius is nearer the occiput, — more remote from the front teeth than in the European; the foramen magnum occipitale lying farther back, the occiput is nearly in a line with the spine; the body is slender, especially in the loins and pelvis, whose cavity likewise is small; the length of the fore-arms and fingers bears a large proportion to that of the os humeri; the os femoris and tibia are more convex, and the edge of the latter, according to a remark of the late Mr. Fyfe of Edinburgh, very sharp; the calves are placed high; the os calcis instead of forming an arch is on a line with the other bones of the foot, which is of great breadth; the toes are long; the penis large and frequently destitute of frænum. Mr. White, from whom many of these remarks are derived, describes the testes and scrotum as small. Mr. Billmann of Cassell has observed that the stomach is shorter, more globular at its cardiac extremity; and the observation is confirmed by Soemmerring, who finds that of the ape still shorter;[c] the skin is thicker,[d] and, finally, the term of life generally shorter, than in Europeans.

Nearly all these facts demonstrate rather a less distance of the Negro than of the European from the brute creation. But with an inferiority to the Caucasians so slight if compared with his immense superiority over the most intelligent brutes, so insensibly running into the Caucasian and all the other varieties, so liable to innumerable diversities of conformation as well as bearing some resemblance to brutes, and so certainly bearing no more resemblance to them in some points nor so much in others as many tribes of other varieties, the poor negro might justly class those of us who *philosophically* view him as merely a better sort of monkey, or who desire to traffic in his blood, not only below himself but below apes in intellect, and below tigers in feeling and propensity.

> "Indica tigris agit rabida cum tigride pacem
> Perpetuam. Sævis inter se convenit ursis." [e]

[c] *Mem. of the Bavarian Acad. of Sciences*, vol. viii. p. 77. sqq.

[d] The temperature of the Negro has been said to be two degrees cooler than that of Europeans, and the voluptuous therefore to prefer a Negress in summer, a fair Circassian in spring and autumn, and an European brunette in winter.

[e] Juvenal. *Sat.* xv. 163.

"The unconscious admiration which that traveller detected himself in bestowing upon the native beauties, affords," says the writer of a critique of Major Denham's *Travels in Africa*,[d] "one more example of this truth, that, however much Europeans may have doubted whether negroes were men, there has never been a difference of opinion as to whether negresses were women."

The skin of the negro has a peculiar velvet-like softness, and is lubricated by an oily secretion.

The Malays have but little hair upon the chin, and possess a great development of the parts of the head above the ears.

The Mongolians are remarkably square and robust; their shoulders high; their extremities short and thick.

The Americans have small hands and feet, and are nearly destitute of beard. Shorter in the forehead than the Mongolians, they have not so great intellectual distinction.

Not only have the five varieties their distinctive characteristics, but the different nations comprehended in each variety have each their peculiarities, both mental and corporeal: among the Caucasians for example, the Germans, French, Spaniards, and English are extremely different from each other. Nay, the provinces of the same country differ, and the families of the same province, and, in fact, every individual has his own peculiar countenance, figure, constitution, form of body, and mental character.

A QUESTION here presents itself. — Are the differences among mankind to be ascribed to the influence of various causes upon the descendants of two, — or of more, but all similar, primary parents; — or to original differences in more than two primary parents?

This being a physical subject, is now always physically investigated, without reference to the Bible, except as an historical work, in conformity both with the opinion of Locke, that only matters above human reason are the proper subjects of revelation; and of Bacon, that religious and philosophical enquiry should be kept separate, and not pompously united.[e] A true revelation cannot suffer by the progress of philosophy; but philosophy

[d] *Westminster Review*. 1826.

[e] See supra, p. 72. 75. sq.

has seriously suffered by ignorant appeals to Scripture. Besides, many will not listen to arguments from Scripture in matters of philosophy, alleging the want of proof of inspiration. Dr. Bostock, one of the most careful and amiable of enquirers, does not hesitate to say, that " we do not find that the writer of the Book of Genesis lays claim to any supernatural source of information with respect to natural phenomena, while the whole tenor of his work seems to show, that on such topics he adopted the opinions which were current among his contemporaries." [f]

In favour of the opinion that we all are brothers, it may be urged, — 1. The universal simplicity of nature's causes would induce us to imagine that, as, if the varieties among us are accidental, two individuals were evidently sufficient for the production of the rest of mankind, no more than two were originally created. Nor should I deduce a contrary presumptive argument from the length of time during which immense portions of the earth must have thus remained unpeopled. One of nature's objects seems the existence of as much successive life as possible, whether animal or vegetable, throughout the globe. For this purpose, every species of animal and vegetable possesses an unlimited power of propagation, capable of filling the whole world, were opportunity afforded it. The opportunities of exertion are indeed very scanty, compared with the power: climate, soil, situation, may be unfavourable; one vegetable, one animal, stands in the way of another; even the impediments to the increase of some, act through them as impediments to others. The incessant tendency of the power of multiplication to exert itself, seizes every opportunity the moment it is presented, and thus, though every living object has a fixed term of existence, and may be carried off much earlier by innumerable circumstances, all nature constantly teems with life. [g] The slow increase of mankind could not inter-

[f] *An Elementary System of Physiology*, vol. iii. p. 286.

[g] From this physiological fact it follows, that if a species is not kept down by disease or violence, or, as should be the case with mankind, by good feeling, to such numbers as can find support, the excess must regularly perish. To vegetables this can be no cruelty. As all the brute creation are preyed upon, their numbers may be always sufficiently thinned without starvation. Violent deaths are too insignificant to operate much in restraining the numbers of mankind, and terrible as is the havoc of disease, the rapid increase of nations, who can command any extent of land they require for food, proves *it* not to be the great restrainer of population. Starvation, however, is not necessary to limit our numbers, be-

fere with this apparent object of nature; the deficiency of our race must have invariably been fully compensated by the opportunities which it afforded for the multiplication of other existences: for that man alone was not designed to enjoy the earth, is shown by the vast tracts of land still but thinly peopled. The infinitely rare opportunities afforded for the maturity of the intellectual and moral powers born with every human being, may afford still greater surprise than the extent of country unoccupied by man.

2. *Analogical and direct facts* lead to the conclusion that none of the differences among mankind are so great as to require the belief of their originality.

Animated beings have a general tendency to produce offspring resembling themselves. in both mental and corporeal qualities.

> "Fortes creantur fortibus et bonis;
> Est in juvencis, est in equis patrum
> Virtus: nec imbellem feroces
> Progenerant aquilæ columbam." [h]

An exception occasionally occurs, much more frequently, we are told, in the domestic than the wild state,—the offspring differs in some particular from the parents; and by the force of the general tendency transmits to its offspring its own peculiarity. By selecting such examples, a breed peculiar in colour, figure, the form of some one part, or in some mental quality, may be produced. Thus, by killing all the black individuals which appear among our sheep and breeding from the white only, our flocks are white; while, by an opposite practice pursued in some countries, they are black: thus a ram accidentally produced on a farm in Connecticut, with elbow-shaped fore-legs and a great

---

cause it is the imperious duty of every man to abstain from getting children unless he has property or work sufficient to feed them when they come into the world.

These palpable facts have been luminously stated by a celebrated member of my own college at Cambridge, and how any one can deny them, or pretend there is impiety in Mr. Malthus's *Essay on Population*, I cannot comprehend. Mr. Mills (Supp. to *Encyclop. Brit.* art. Savings Banks), considers that the addition made by Mr. Malthus to the admitted doctrine of population being commensurate with food is, that man's tendency to marry, and prolific powers, cause a greater number to be born than can be fed.

[h] *Horace*, l. iv. od. 4.

shortness and weakness of joint indeed in all four extremities, was selected for propagation, and the ἀγκὼν breed, unable to climb over fences, is now established:[i] thus some breeds of hares have horns like the roebuck: the Dorking fowl has two hind claws; and fowls in short are bred in every conceivable variety.[k] Individuals, distinguished from others by no greater differences than those which thus spring up accidentally, cannot be supposed to belong to a separate species. Upon the compa-

[i] Thomson's *Annals of Philosophy*, No. 2.

[k] The offspring most frequently resembles both parents, but the proportion of resemblance to each, both on the whole and in regard to particular parts, is various, — some children favouring the father most, some the mother, though usually resembling each enough to preserve a family likeness, — some parts being as it were an equable compound of the same in both parents, (as the skin in the mulatto offspring of a black and white,) some an unequal compound, (as when the offspring of a black and white is white with patches of black or with merely a black penis, *Phil. Trans.* vol. 55. Bartholin, *Hist. Anat.* Schurig, *Spermatologia*, p. 146.) and others again similar to the same as seen in one parent only; and it is remarkable that the resemblance to the parents, whether in regard to common or uncommon peculiarity, is occasionally not observed in the immediate offspring, but re-appears in the third or even a later generation.

As the different properties of both parents are on the whole pretty well blended in the offspring, we may, by breeding successively from offspring and one of the original parents, at length produce an offspring exactly resembling this parent. (590.) Some dissolute Europeans are said to have begun with a black woman, and copulated with their offspring till they made her the great grandmother of a white.

National features, form, and in a great measure even character, arise from a nation marrying among themselves, and will be more marked in proportion to the rarity of connection with foreigners. Hence the amazing peculiarity of the Jewish race.

The advantage of crossing breeds is well known, and may be explained by the transmission of the parent's qualities. If any unfavourable deviation in structure or constitution occurs, and is transmitted, and the descendants who receive it hereditarily intermarry, the deviation is doubly enforced in their offspring: but if a connection is made with another family or breed it is, on the contrary, diluted. Could a race, however, have all its wants well supplied, and, at the same time, have no unhealthful habit, so as to *acquire* no tendency (p. 459.) to unfavourable deviation, I do not think that the soundness of breeds would require crosses. The Arabians never allow the mares of the noble race to be covered by any but stallions of their own rank, yet the excellence of the breed is maintained. (D'Arvieux, *Travels in Arabia*, p. 168.) Their horses have every comfort, and yet are not subjected, like our domestic animals and most of ourselves, to unnatural habits. The degeneracy of many plants unless their *soil* is changed, is quite another circumstance.

rison of these differences depends the analogical argument first employed by Blumenbach. Finding the ferret *(mustela furo)* to differ from the pole-cat *(m. putorius)* by the redness of its eyes, he concludes it is merely a variety of the same species, because instances of this deviation are known to occur accidentally in other animals; but he concludes the African elephant is of a species distinct from the Asiatic, because the invariable difference of their molar teeth is of a description which naturalists have never found accidental. Now there exist among mankind no differences greater than what happen occasionally in separate species of brutes.

The colours of the animals around us, horses, cows, dogs, cats, rabbits, fowls, are extremely various, — black, white, brown, grey, variegated.

The hair of the wild Siberian sheep is close in summer, but rough and curled in winter;[l] sheep in Thibet are covered with the finest wool, in Ethiopia with coarse stiff hair;[m] the bristles of the hog in Normandy are too soft for the manufacture of brushes;[n] goats, rabbits, and cats of Angouri, in Anatolia, have very long hair, white as snow and soft as silk.[o]

The head of the domestic pig differs as much from that of the wild animal, as the Negro from the European in this respect;[p] so the head of the Neapolitan horse, denominated ram's head on account of its shape, from that of the Hungarian animal, remarkable for its shortness and the extent of its lower jaw;[q] the cranium of fowls at Padua is dilated like a shell, and perforated by an immense number of small holes;[r] cattle and sheep in some parts of our own country have horns, in others not; in Sicily sheep have enormous horns;[s] and in some instances this animal has so many, as to have acquired the epithet polyceratous.

The form of other parts is no less various. In Normandy, pigs have hind-legs much longer than the fore,[t] at the Cape of Good Hope, cows have much shorter legs than in England;[u] the difference between the Arabian, Syrian, and German, horses is suffi-

[l] Pallas, *Spicileg. Zoologica.*

[m] Blumenbach, l. c. § 28.

[n] l. c. [o] l. c. [p] l. c. [q] l. c.

[r] Pallas, *Spic. Zool.* fasc. iv. p. 22. Sandifort, *Museum Anatomicum Acad.* Lugd. Batav. t. i. p. 306.

[s] Blumenbach, l. c. § 30. [t] l. c. [u] l. c.

ciently known; the hoofs of the pig may be undivided, bisulcous, or trisulcous.

These are regarded by naturalists as but accidental varieties, yet they equal or surpass the varieties existing among mankind. We are consequently led by analogy to conclude, that the differences of nations are not original but acquired, and impose no necessity for believing that more than one stock was at first created.

3. *Direct facts* harmonise with this conclusion. All races run insensibly one into another, and therefore innumerable intermediate examples occur where the distinction between two varieties is lost. Again, no peculiarity exists in any variety which does not show itself occasionally in another. Many instances of these facts have been already related (page 556, note [o]). The difficulty of regarding the negro as of the same stock with ourselves vanishes on viewing these circumstances, and on reflecting that he and ourselves are two extremes, one of which may have sprung from the other by means of several intermediate deviations, although experience may not justify us in supposing any single deviation of sufficient magnitude.[x] Lastly, both the

[x] In regard to colour, however, the Albino proves how great a change may take place in one generation. In the *Memoirs of the London Medical Society*, (vol. iii.) is described a case, where not only patches of the hair of the head of an European changed from black to perfect white, first on one side and then on the other, and in the course of seven years every hair became white excepting the eyebrows, but the skin also from being swarthy became fair. (I may add that the irides remained unchanged, and that another case is annexed to it where half the hair was black and lank, and the other half light and frizzled.) I recollect accounts of other persons, who belonged to the dark races, turning white, — one of a negress, in Maryland, forty years of age, who had been turning white during the last fifteen years, and had become scarcely inferior in any part of her surface to an European, and was still changing, (*Phil. Trans.* vol. li.), — one in the *Manchester Memoirs*, (vol. v. P. 1.) of a negro about forty years of age, whose skin had so changed in two years that the narrator was convinced that all the black portions remaining did not exceed a square foot, and the change still continued to proceed very rapidly, — one of a man, born in Bengal, near sixty years of age, who left India in his tenth year, and had for nine years been changing to white, (Dr. Duncan, jun. *Reports in the Practice of the Clinical Ward of the Royal Infirmary of Edinburgh*. 138.), — one mentioned by the Duc de Rochefoucalt Liancourt. (*Travels through the United States*, vol. v. p. 124. sqq.) The duke says, that the change had been proceeding for three years, was still going on, and the wool of the head had changed to European hair, and that several such

males and females of all the varieties breed together readily and in perpetuity,[y]— an assertion which cannot be made in regard to any different species of brutes.

The cause of the differences of our species has been more or less sought for in climate, alone or in conjunction with other external circumstances, by Aristotle, Hippocrates, Cicero, Pliny, Plutarch, Galen, nearly all the Greek and Roman historians and poets, Montaigne, Montesquieu, Buffon, Zimmerman, Blumenbach, Dr. Smith of America, &c. Lord Kaimes denied the power of these circumstances to produce the diversities of either mind or body; and Hume expressly wrote an essay to prove the insufficiency of climate with respect to the varieties of national character. Now the intensity of light unquestionably affects the colour of the surface, although not to the degree of Ethiopian blackness; heat the texture and growth of the hair; and quantity of nourishment the size. But the effects of these circumstances are generally considered superficial, even on animals necessarily less protected against their influence than man. The skulls of foxes belonging to northern regions are not different from those of France or Egypt: the tusks of the elephant, and the horns of the stag and rein-deer, may acquire a larger size when the food is

---

instances, though less complete, had occurred. Another will be seen in the *Journal of the Royal Institution*, No. xii. p. 379. A Sussex girl was, a few years ago, a patient in St. Thomas's Hospital, whose family were all white, but whose left shoulder, arm, and hand, were of a negro-blackness, except that a stripe of white ran between the elbow and arm-pit. (Dr. Well's *Works*.) I once saw a young Welsh-woman whose left upper arm was remarkably dark. The shoulder was almost as black as a negro's, but became gradually lighter down the arm, and abruptly terminated an inch below the elbow. The greater part of the upper arm was covered with fine scanty hairs. A white woman in twenty years became as black as a negress, without any evident reason, according to a statement in the *London Medical and Physical Journal*. (1811. p. 24.), — another suddenly became black from mental distress, and remained so; and the blackness was not from jaundice, congestion of blood, &c.; but a change in the colouring matter of the rete mucosum. *Journal Général*, vol. lxviii., where a second is referred to. And other such cases may perhaps be discovered, though those which I have read appear to have been instances of cutaneous disease.

[y] Examples have already been mentioned (563. B.) of what is a still stronger argument, — the *simultaneous* production of two individuals of different varieties, — of a negro and a Caucasian, by the same mother.

more favourable to the production of ivory or horn, but the number and articulations of the bones, and the structure of the teeth, remain unaltered.[z] Nor are these changes, any more than those induced by mechanical means, as pressure, division, &c. transmitted to the offspring: the child of the most sunburnt rustic is born equally fair with other children; even all the children among the Moors are born white and acquire the brown cast of their fathers only if exposed to the sun;[a] although the Jews have most religiously practised the rite of circumcision from the days of Abraham, their foreskin still remains to be circumcised.[b] Were it therefore true that all dark nations are the inhabitants of hot climates, as the confined knowledge of the ancients led them to believe, it would still be untrue that the change effected, for instance, in the colour of the parent's skin, had descended to the offspring. But modern discovery has made us acquainted with light nations inhabiting the warmest regions, with dark nations inhabiting the coldest, and with others of various shades of colour although in the same climate.[c] Many protected parts are as

[z] Cuvier, *Discours Préliminaire aux Recherches sur les Ossemens Fossiles des Quadrupèdes*. *Natural varieties* only are meant. Local situation can produce the most intimate structural *diseases;* witness Cretinism.

[a] Poiret, *Voyage en Barbarie*, t. i. p. 31. Vide Blumenbach, l. c.

[b] Paley, *Natural Theology*, c. 23. p. 472.

[c] Lord Kaimes, M. de Virey, and Dr. Prichard, have quoted many instances of these facts. "We found," says Humboldt, "the people of the Rio Negro swarthier than those of the lower Orinoco, and yet the banks of the first of these rivers enjoy a much cooler climate than the more northern regions. In the forests of Guiana, especially near the sources of the Orinoco, are several tribes of a whitish complexion, the Guiacas, Guajaribs and Arigues, of whom several robust individuals exhibiting no symptom of the asthenical malady which characterises Albinos, have the appearance of true Mestizos. Yet these tribes have never mingled with Europeans, and are surrounded with other tribes of a dark brown hue. The Indians, in the torrid zone, who inhabit the most elevated plains of the Cordilleras of the Andes, and those who are under the 45° of south latitude, have as coppery a complexion as those who under a burning climate cultivate bananos in the narrowest and deepest vallies of the Equinoctial region. We must add that the Indians of the mountains are clothed, and were so long before the conquest, while the aborigines, who wander over the plains, go quite naked, and are consequently always exposed to the perpendicular rays of the sun. I could never observe that in the same individuals those parts of the body which were covered were less dark than those in contact with a warm and humid air. We every where perceive that the colour of the American depends very little on he local position in which we see him. The Mexicans, as we have already observed, are more swarthy than the Indians of Quito and New Granada, who

black as those which are exposed. Nor are the varieties of mankind more dependent upon the varieties of food.

But with civilisation and barbarism they appear certainly connected. We should beforehand be inclined to imagine that the most excellent development of every animated species would be effected where all its wants were best supplied, its powers all duly called forth, and all injurious or unpleasant circumstances least prevalent: and *vice versa*. Every one knows the effect of cultivation in the vegetable kingdom. But experience teaches us that changes brought about in an animal after birth are not in general transmitted to the offspring: the causes of change in a species must therefore operate, not by altering the parents, but by disposing them to produce an offspring more or less different from

---

inhabit a climate completely analogous, and we even see that the tribes dispersed to the north of the Rio Gila are less brown than those in the neighbourhood of the kingdom of Guatimala. This deep colour continues to the coast nearest to Asia, but under the 54° 10′ of north latitude, at Cloak Bay, in the midst of copper-coloured Indians, with small long eyes, there is a tribe with large eyes, European features, and skin less dark than than that of our peasantry." *Political Essay on New Spain*, translated.

The Jews settled in the neighbourhood of Cochin "are divided into two classes, called the Jerusalem or white Jews, and the ancient or black Jews." — "The white Jews look upon the black Jews as an inferior race, and not as a pure cast, which plainly demonstrates that they do not spring from a common stock in India." Buchanan, *Christian Researches in Asia*, 219, &c.

The white appear to have resided there upwards of seventeen hundred years.

Dr. Shaw and Mr. Bruce describe a race of fair people in the neighbourhood of Mount Aurasius, in Africa, who, "if not so fair as the English, are of a shade lighter than that of any inhabitants to the southward of Britain. Their hair also was red, and their eyes blue." They are imagined to be descendants of the Vandals. Bruce, *Travels*.

The Samoiedes, Greenlanders, Laplanders, Esquimaux, &c. are very swarthy; nay, some of the Greenlanders are said to be as black as Africans.

"Do we not in fact behold," says M. de Virey, "the tawny Hungarian, dwelling for ages under the same parallel and in the same country with the whitest nations of Europe; and the red Peruvian, the brown Malay, the nearly white Abyssinian, in the very zones which the blackest people in the universe inhabit? The natives of Van Diemen's land are black, while Europeans of the corresponding northern latitude are white, and the Malabars in the most burning climate, are no browner than the Siberians. The Dutch, who have resided more than two centuries at the Cape of Good Hope, have not acquired the sooty colour of the native Hottentots; the Guebres and Parsees, marrying only among themselves, remain white in the midst of the olive-coloured Hindus." J. T. Virey, *Histoire Naturelle du genre humain*, t. i. p. 124.

themselves. Such is John Hunter's view of the question,[d] and it is certainly confirmed by every fact.[e] Uncivilized nations exposed to the inclemency of the weather, supported by precarious and frequently unwholesome food, and having none of the distinguished energies of their nature called forth, are generally dark coloured and less distant from brutes in conformation; while those who enjoy the blessings of civilisation, *i.e.* good food and covering, with mental cultivation and enjoyment, generally acquire in the same proportion the Caucasian characteristics. The different effects of different degrees of cultivation, says Dr. Smith, "are most conspicuous in those countries in which the laws have made the most complete and permanent division of ranks. What an immense difference exists in Scotland between the chiefs and the commonalty of the highland clans. If they had been separately found in different countries, the philosophy of some writers would have ranged them in different species. A similar distinction takes place between the nobility and peasantry of France, Spain, of Italy, of Germany. It is even more conspicuous in eastern nations, where a wider difference exists between the highest and the lowest classes in society. The naires or nobles of Calicut, in the East Indies, have with the usual ignorance and precipitancy of travellers been pronounced a different race from the populace; because the former, elevated by their rank, and devoted only to martial studies and achievements, are distinguished by that manly beauty, and elevated stature so frequently found with the profession of arms: especially when united with nobility of descent; the latter poor and laborious, and exposed to hardships without the spirit or

[d] I fear that John Hunter has not generally the credit of this observation, but the following passage shows it to be clearly his. "As animals are known to produce young which are different from themselves in colour, form, and disposition, arising from what may be called the unnatural mode of life, it shows this curious power of accommodation in the animal economy, that although education can produce no change in the colour, form, or disposition of the animal, yet it is capable of producing a principle which becomes so natural to the animal that it shall beget young different in colour and form; and so altered in disposition, as to be more easily trained up to the offices in which they have been usually employed; and having these dispositions suitable to such changes of form." Hunter, *On the Wolf, Jackall, and Dog*, l. c.

[e] May not some circumstances that produce a change in the offspring by acting *through* the parent, produce the same change likewise *in* the parent, although the *change* in the latter is *not* the cause of the change in the offspring?

the hope to better their condition, are much more deformed and diminutive in their persons, and in their complexion much more black. In France, says Buffon, you may distinguish by their aspect not only the nobility from the peasantry, but the superior orders of nobility from the inferior, these from citizens, and citizens from peasants."—" The field slaves in America," continues Dr. Smith, " are badly clothed, fed, and lodged, and live in small huts on the plantations, remote from the example and society of their superiors. Living by themselves, they retain many of the customs and manners of their ancestors. The domestic servants, on the other hand, who are kept near the persons, or employed in the family of their masters, are treated with great lenity, their service is light, they are fed and clothed like their superiors, they see their manners, adopt their habits, and insensibly receive the same ideas of elegance and beauty. The field slaves are in consequence slow in changing the aspect and figure of Africa. The domestic servants have advanced far before them in acquiring the agreeable and regular features, and the expressive countenance of civilised society. The former are frequently ill-shaped, they preserve, in a great degree, the African lips, and nose and hair. Their genius is dull, and their countenance sleepy and stupid. The latter are straight and well proportioned, their hair extended to three or four, sometimes even to six or eight inches : the size and shape of their mouth handsome, their features regular, their capacity good, and their look animated "[f]

Dr. Prichard has " been assured by persons who have resided in the West Indies, that a similar change is very visible among the Negro slaves of the third and fourth generation in those islands, and that the first generation differs considerably from the natives of Africa."[g]

The South Sea Islanders, who appear to be all of one family, vary according to their degree of cultivation. The New Zealanders, for example, are savages and chiefly black ; the New Hollanders, half civilised and chiefly tawny ; the Friendly Islanders are more advanced and not quite so dark, several are lighter than olive colour, and hundreds of European faces are found among them.

[f] *On the Causes of the Variety in the Complexion and Figure of the Human Species*, p. 85. sq.

[g] l. c. ed. 2. t. ii. p. 565. sq.

The people of Otaheite and the Society isles are the most civilised and the most beautiful: the higher orders among them have a light complexion and hair flowing in ringlets; the lower orders, less cultivated, are less pleasing.

"The same superiority," says Captain King,[h] "which is observable in the Erees (nobles) throughout the other islands, is found also here (Owyhee). Those whom we saw were, without exception, perfectly well formed; whereas the lower sort, besides their general inferiority, are subject to all the variety of make and figure that is seen in the populace of other countries."[i]

Climate, however, has not been shown to have no effect: but its power, being in itself not generally very considerable, cannot be strongly manifested when opposed. In fact, a diminution of the sun's influence does dispose to the production of light varieties: the inhabitants of hilly situations are, cæteris paribus, fairer than the people below, and persons of the same tribe and degree of civilisation lighter in the northern parts of Europe and Asia than those in the more southern; whiteness, too, is very common in the north among animals which nearer the equator are variously coloured; a pair of brown mice kept in a dark place are said to generate a white offspring. Blumenbach mentions that small birds fed on hemp-seed in a chamber, become black.[k] Some statements have been lately made respecting New South Wales, that show the influence of the climate of that country to be considerable.

"It appears, indeed, that the change which takes place in the physical constitution of *all kinds* of animals on transplantation to New South Wales, is something quite astonishing. It was long since remarked, that prostitutes who had never borne children in Europe, became prolific mothers in the Australian colonies, and that married women who had long left off child-bearing, recommenced, in some cases even at the advanced period of fifty years, after a short residence in these regions; and the observation appears to be confirmed, that not only the human race, but most of the quadrupeds produced from animals imported, improve their breed and increase considerably in size. Mr. Dawson, the intelligent manager of the Australian Agricultural Company, thus

[h] Cook, *Voyages*, vol. iii. book v. c. 7.

[i] If the kingdom of Hayti continues, some highly interesting physiological questions will be determined: — We shall know what cultivation the African race is capable of, and what influence civilisation has upon the system of successive generations.

[k] *Med. Gazette*, No. 2.

writes in a private journal with which we have been favoured. 'Both the climate and the soil appear by nature intended to produce fine wool and fine animals too, even from the worst beginnings. The latter seems a paradox. The extensive range that can be afforded to every animal keeps it in good condition, and, perhaps, the native grasses may have more of good in them than their appearance indicates. However this may be, the climate clearly has a wonderful effect on the size of all animals, even upon man, who is almost universally tall here, although born of diminutive parents. From this I am led to believe that the climate governs chiefly, and thus every breeding animal introduced here will attain a size not known in Europe. From what I know of the origin of the breed of horses introduced here, and the size of the stock that has almost promiscuously been produced from them, I have strong grounds for inferring that the produce of such horses as we have imported will be something extraordinary.'"[1]

The late inestimable Bishop Heber, in speaking of India, says, "It is remarkable, to observe how surely all these classes of men (whites, — Persian, Greeks, Tartars, Turks, and Arabians), in a few generations, even without any intermarriage with the Hindoos, assume the deep olive tint, little less dark than a negro, which seems natural to the climate. The Portuguese have, during three hundred years' residence in India, become as black as Caffres. Surely this goes far to disprove the assertion which is sometimes made, that climate alone is insufficient to account for the difference between the negro and the European. It is true that in the negro are other peculiarities which the Indian has not, and to which the Portuguese colonist shows no symptom of approximation, and which undoubtedly do not appear to follow as naturally from the climate as that swarthiness of complexion which is the sole difference between the Hindoo and the European. But if heat produces one change, other peculiarities of climate may produce other and additional changes, and where such peculiarities have three or four thousand years to operate in, it is not easy to fix any limit to their power. I am inclined, after all, to suspect that our European vanity leads us astray in supposing that our own is the primitive complexion,

[1] *Quarterly Review*, Jan. 1828. p. 7. Review of *Two Years in New South Wales, &c.* by P. Cunningham, surgeon, R. N. 1827.

which I would rather suppose was that of the Indian, half way between the two extremes, perhaps the most agreeable to the eye and instinct of the majority of the human race. Colder climate and a constant use of clothes, may have bleached the skin as effectually as a burning sun and nakedness may have tanned it: and I am encouraged in this hypothesis by observing that of animals the natural colours are generally dusky and uniform, while whiteness and a variety of tint almost invariably follow domestication, shelter from the elements, and a mixed and unnatural diet. Thus, while hardships, additional exposure, a greater degree of heat, and other circumstances with which we are unacquainted, may have deteriorated the Hindoo into a negro, opposite causes may have changed him into the progressively lighter tints of the Chinese, the Persian, the Turk, the Russian, and the Englishman."[m]

Volney gives us a singular instance of the power of climate upon different races; not, indeed, in producing variety, but in mysteriously affecting generation.

"During five hundred and fifty years that there have been Mamlouks in Egypt, not one of them has left subsisting issue; there does not exist one single family of them in the second generation; all their children perish in the first or second descent. Almost the same thing happens to the Turks; and it is observed that they can only secure the continuance of their families, by marrying women who are natives, which the Mamlouks have always disdained. Let the naturalist explain why men, well formed, and married to healthy women, are unable to naturalize on the banks of the Nile, a race born at the foot of Mount Caucasus! and let it be remembered, at the same time, that the plants of Europe in that country are equally unable to continue their species! Some may refuse to believe this extraordinary fact, but it is not on that account less certain; nor does it appear to be new. The ancients have made observations of the same nature: thus, when Hippocrates asserts, that among the Scythians and Egyptians, all the individuals resemble each other, though they are like no other nations; when he adds, that in the countries inhabited by these two races of men, the climate, seasons, elements, and soil possess an uniformity no where else to be found,

[m] *Narrative of a Journey through the Upper Provinces of India, from Calcutta to Bombay*, by the late Reginald Heber, D.D. Lord Bishop of Calcutta, p. 54. sq.

does he not recognize that kind of exclusion of which I speak? When such countries impress so peculiar a character on every thing native, is it not a reason why they should reject whatever is foreign? It seems, then, that the only means of naturalizing animals and plants would be to contract an affinity with the climate, by alliance with the native species; and this, as I have before said, the Mamlouks have constantly refused. The means, therefore, by which they are perpetuated and multiplied, are the same by which they were first established; that is to say, when they die, they are replaced by slaves brought from their original country." [n]

Being curious on this point, and having a most intelligent and valued friend who lately travelled in Turkey, Syria, and Egypt, and even spent seven months in the Desert of Arabia, I applied to him for information, and received the following note: —

"Dear Elliotson, *Limmer's Hotel, March 3.*

"I have just received your note, and have great pleasure in giving you what information I am able on the subject of the Europeans in Egypt. You asked me yesterday if I had not told you Volney was incorrect in the statement he has made in p. 108. concerning the Mamlouks? I do not remember having told you any thing to that effect: the subject which he seems to have been misinformed upon is the climate of Syria, which does not interest you.

"From the various enquiries I made in Egypt I consider Volney to be perfectly correct. The persons whom I asked had never read his work, and till I asked them had never given their attention to the subject; yet still they could not bring one instance to their recollection of the children (of two whites) born in the country ever coming to maturity. I was also told that children begotten by Europeans out of natives (a circumstance which, however, rarely happens, owing to the Copts and Arabs being very particular on that subject) entirely lose their appearance of European origin in the third generation. The physiognomy of the Copts is very striking; I never remember seeing the least European mixture, which would be visible if they had made alliances with the Turks who are as different in the form of face as can well be imagined, —

[n] *Voyage en Egypte et en Syrie,* t. i. p. 87. sq.

the Turks have Roman noses; the Georgians Grecian; the Mamlouks both; but the Copts are *snubs*.

"I was told at Damietta, the port on the eastern branch of the Nile, that an Italian family had flourished amazingly; afterwards I heard the mother was a Maltese, which, if true, more strongly corroborates the fact, as the Maltese are supposed to be of Arabian origin: they speak a kind of jargon so like Arabic as to make themselves understood by the natives on their arrival in Egypt.

"What Volney also says about the vegetables is equally true. When I left Cairo, a gardener hearing that I was going to Jaffa and Damascus, and likely to return, begged me to bring him melon and cauliflower seed, as, though those plants thrive exceedingly well in Egypt, unless the seed be renovated constantly, it degenerates so as quite to become another plant. This is also the case, I understand, with the Brussels sprouts, so celebrated in the Netherlands. Plants raised from seed from Brussels thrive well in this country; but seed saved here, though it ripens thoroughly, greatly degenerates in the second generation.

"The race of Mamlouks has been entirely destroyed by the present Pacha, Mahommed Ali. Only a few escaped the general massacre in the citadel, and fled to Dongola. These few have been gradually dying off. When I was in Cairo I heard from a person lately arrived from Abyssinia that only a *very* few were left. One old man, the only *one* in Cairo, I used to see daily in a public garden. I had some conversation with him several times, but he was quite superannuated, and could give no information. In fact, had he been capable, his life would not have been spared.

"Ever your's most truly,
"J. S. Crompton."

The hereditary transmission of habits is well described by a recent author.

"Every one conversant with beasts knows that not only their natural, but many of their acquired qualities are transmitted by their parents to their offspring. Perhaps the most curious example of the latter may be found in the pointer.

"This animal is endowed with the natural instinct of winding game, and stealing upon his prey, which he surprises, having first made a short pause, in order to launch himself upon it with more security of success. This sort of semicolon in his proceedings man converts into a full stop, and teaches him to be as much pleased at seeing the bird or beast drop by the shooter's gun as at taking it himself. The staunchest dog of this kind, and the original pointer, is of Spanish origin, and our own is derived from this race, crossed with that of the fox-hound or other breed of dogs, for the sake of improving his speed. This mixed and factitious race of course naturally partakes less of the true pointer character; that is to say, is less disposed to stop, or, at least, he makes a shorter stop at game. The factitious pointer is, however, disciplined in this country into staunchness; and what is most singular, this quality is in a great degree inherited by his puppy, who may be seen earnestly standing at pigeons or swallows in a farm-yard. For intuition, though it leads the offspring to exercise his parent's faculties, does not instruct him how to direct them. The preference of his master afterwards guides him in his selection, and teaches him what game is better worth pursuit. On the other hand, the pointer of pure Spanish race, unless he happens to be well broke himself, which, in the south of Europe seldom happens, produces a race which are all but unteachable, according to our notions of a pointer's business. They will make a stop at their game as natural instinct prompts them, but seem incapable of being drilled into the habits of the animal which education has formed in this country, and has rendered, as I have said, in some degree, capable of transmitting his acquirements to his descendants.

" Acquired habits are hereditary in other animals besides dogs. English sheep, probably from the greater richness of our pastures, feed very much together; while the Scotch sheep are obliged to extend and scatter themselves over their hills for the better discovery of food. Yet the English sheep, on being transferred to Scotland, keep their old habit of feeding in a mass, though so little adapted to their new country: so do their descendants; and the English sheep is not thoroughly naturalized into the necessities of his place till the third generation. The same thing may be observed as to the nature of his food, that is observed in his mode of eating it. When turnips were introduced from England into Scotland, it was only the third generation which heartily adopted this diet, the first having been starved into an acquiescence in it. In the same manner it required some years to establish the English practice of bringing up calves by hand in Scotland; the first who were so fed being cheated into swallowing milk, as the English calves at first are, by dipping the finger in the bowl and giving it the animal to suck. Nor was this mode of administering nourishment (slowly and reluctantly admitted by Lowland calves) ever, I believe, cordially adopted by their mountain kindred. The Highland beast has shown himself the worthy imitator of the Highland man, and is as obstinate in his opposition to this as his Celtic master is to any other southern improvement which can be offered to him."[o]

The effect of civilization on corporeal strength was proved by Peron,[p] who ascertained, by means of Regnier's Dynamometer, the bodily power of the complete savage of Van Diemen's land to be inferior to that of the more cultivated New Hollander, of the latter to that of the still more cultivated inhabitant of Timor, and of the last very considerably to that of Europeans. The weakest Frenchman was equal in the hands to the strongest man of Van Diemen's Land, and the weakest Englishman stronger than the strongest New Hollander: the *average* strength of Europeans in the loins exceeded that of the most powerful individuals of either Van Diemen's Land, New Holland, or Timor.

On account of all these facts, and of the consideration that a child is continually produced differing remarkably from both its parents and that such an individual born in ancient times might have given origin to a large nation resembling himself, I can discover no reason for not believing that we are sprung from two parents.

Perfection, in other words, the highest compatible point of utility or agreeableness, or of both, is nature's universal aim in her productions, but it is in general obtained slowly, and the more so in proportion to the excellence or degree of the qualities to be perfected. Animals and vegetables have to pass one period before they burst into birth, and another before their full powers and proportions are reached; and man, whose perfections are very excellent, arrives at his acmé very late.

[o] *Thoughts and Recollections by one of the last century.*

[p] *Voyages des Découvertes aux Terres Australes.*

It is in this respect with species as with individuals, — their improvement is gradual.

In conformity with such observations, some suppose that all mankind were once so far below the excellence of which they are susceptible, — that this was to be acquired so slowly, that the Caucasian variety once did not exist. They support this opinion by the remark of Mr. Hunter, — that the changes of colour in brutes are always from the darker to the lighter shades, [q] by the numerous instances of individual blacks turning permanently white, whereas individual whites have rarely been known to turn black, and by the asserted probability of the most ancient people of the earth, from whom Europeans must be descended, having been genuine Ethiopians or Negroes. [r]

Those who oppose the opinion of our descent from two parents, urge that the five millions of human beings that may at present exist could not have descended from one pair without a chain of wonders; that accidents, diseases, &c. might have happened to our first parents, and the peopling of the earth would thus have been left to chance; that no reason can be given for mankind wishing to leave their place of birth and traverse continents and oceans, that indeed mankind is generally indisposed to migration;

[q] "Animals living in a free and natural state are subject to few deviations from their specific character; but nature is less uniform in its operations, when influenced by culture. Considerable varieties are produced under such circumstances; of which the most frequent are changes in the colour.

"These changes are always, I believe, from the dark to the lighter tints; and the alteration very gradual in certain species, requiring in the canary-bird several generations; while in the crow, mouse, &c. it is completed in one. But this change is not always to white, though still approaching nearer to it in the young than in the parent; being sometimes to dun, at others to spotted, of all the various shades between the two extremes. This alteration in colour being constantly from dark to lighter, may we not reasonably infer, that in all animals subject to such variation, the darkest of the species should be reckoned nearest to the original; and that where there are specimens of a particular kind, entirely black, the whole have been originally black? Without this supposition it will be impossible, on the principle I have stated, to account for individuals of any class being black. Every such variety may be considered as arising in the cultivated state of animals." Hunter, *On the colour of the pigmentum nigrum of the eye*, l. c. p. 243.

[r] Dr. Prichard, l. c. chap. vii. viii. ix. Rudolphi mentions Pallas, Schelver, Doornik and Link, as supporters of this opinion. We have just seen the sentiments of a Bishop.

and that the supposition is supported by no other authority than "a very improbable Jewish tradition."[s]

I confess myself unable to discover the weight of these assertions.

So high is the power of circumstances to alter the constitution estimated by some writers, that they would have us believe every species and variety in the whole vegetable and animal kingdom to be the same, and to differ solely by modifying influences. Common matter, they contend, becomes vivified under favourable circumstances into vegetable, and then into animal, or at once into animal.[t] Many individuals of the simplest animal race, M. Lamarck argues, gradually acquire more complexity, accordingly as the circumstances in which they may be placed are favourable to the development of various powers and structures. These produce their like, and many of their progeny become variously influenced still farther, and so the change has proceeded till all the varieties of vegetables and animals, from mildew to the banian-tree casting a shadow of 11,000 feet in circumference, from the microscopic animalcule to man and the mammoth, have been produced. The reason that man and the brutes around us appear exactly the same as they are mentioned in the oldest histories, he ascribes to the shortness of the period, long as it seems to us in comparison with our own career of life. The earth, he believes, from its marks of great antiquity, to have existed for innumerable ages, quite long enough to explain all the diversities of animals considered as changes gradually effected; and the remotest ages of which we have records, to be too modern for *obvious* alterations to have been subsequently effected, though change has, doubtless, silently proceeded. The effect of circumstances he illustrates by our tame geese and ducks, which have, with their wildness, lost the power of elevated or protracted flight, and undergone some changes of structure. Upon this doctrine he explains the similarity of structure in all animals, — how every species runs insensibly into others; the modifying influences having

[s] Dr. Rudolphi, professor in the University of Berlin. *Grundriss der Physiologie.*

[t] Blumenbach believes the spontaneous generation of the animalcule *vibrio aceti*, because it is found only in the *artificial* mixture of vinegar and paste. But as animalcules abound in vinegar, why should it not merely be a variety occasioned by the influence of the paste? *Handbuch der Naturges.* th. ix.

operated in infinite degrees, and affected certain parts more than the rest. He considers, that except those races of animals which man has extirpated, the others whose fossil remains attest their former existence, but which are thought to be extinct, really exist at present, but so modified by the evolution of various parts that they appear under the form of new animals.[u]

Great as the power of circumstances is in altering structure and habits, I cannot believe that the kangaroo's peculiarities arose from some animals *happening* to have used their fore-extremities too little, and their hind extremities and tails very much; or the web of aquatic birds, from their progenitors having happened to separate their claws as much as possible in swimming. Spontaneous generation is doubtful, and I think Lamarck's principles apply to the production of varieties only, and those chiefly among the lower species, and that there is neither proof nor probability that the enormous diversities of animals, from man to the animalcule of a vegetable infusion, can be attributed to external circumstances.

Still there is nothing atheistical, but the very highest sublimity, in the conception. We have reason to believe that among the myriads of worlds and systems of worlds in the universe, world after world, and system after system are, like countries, and like animals and vegetables, silently and successively destroyed, and others produced. Our new earth Lamarck imagines to have been endowed by the Creator with such powers that, under certain circumstances, portions of its matter became animated and organised, and these animated portions he imagines to have been endowed with the property of becoming more and more complicated in their structure and excellent in their properties, till in the course of countless ages the world came to abound as it does, in all the varieties of living beings, with the human race at their head.

[u] *Philosophie Zoologique*, vol. ii. Paris, 1809.

POSTSCRIPT.

Page 161. *for* "Oronoco," *read* "the Orinoco."

Page 216. *for* "Meckel's" *read* "Gasser's."

Page 221. Experiments similar to some which have been lately made, were performed above a century and a half ago. In 1673, M. Duverney removed the cerebrum and cerebellum from a pigeon, and found the animal "live some time, search for aliment, &c." He removed the cerebrum from a dog without a fatal result for some time: the removal of the cerebellum was instantly fatal. Yet, by instituting artificial respiration, he sustained life for an hour after the removal of the cerebellum. In one experiment, the dog "lived twenty-four hours, and his heart beat well." The instantly fatal result of the division of the spinal marrow at the first vertebra he prevented also by artificial respiration, and found that "the motion of the heart continued, and the animal could move his body." See *Phil. Trans.* vol. xix.

Page 488. The reference to the *Ed. Med. and Surg. Journal*, should be vol. xvii. The experiments are by Dr. Mayer of Bonn. Those with madder, and on the continuance of the fœtal circulation in warm water, are by Dr. Chapman, and will be found in the *Philadelphia Journal*, No. I.

Page 485. I cannot deny myself the gratification of stating, that since this Note was written I have witnessed the complete extirpation of a scirrhous and ulcerated uterus, fundus, cervix and os, through the vagina, by Dr. James Blundel, without injury of any neighbouring organ, hemorrhage, or the least unpleasant circumstances either during or after the operation; and that the woman is now at the end of three weeks perfectly well.

THE END.

London:
Printed by A. & R. Spottiswoode,
New-Street-Square.